Montana Department of
ENVIRONMENTAL QUALITY

CIRCULAR DEQ 1

STANDARDS
FOR
WATER WORKS

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FOREWORD

The Board of Environmental Review of the State of Montana as authorized by 75-6-103(2)(f), MCA, hereby adopts the following standards for water works.

Preceding the standards are policy statements of the Board concerning water works design, practice, or resource protection. Those policy statements recommending an approach to the investigation of innovative treatment processes have not been included as part of the standards because sufficient confirmation has not yet been documented to allow the establishment of specific limitations or design parameters.

These standards, consisting of proven technology, are intended to serve as a guide in the design and preparation of plans and specifications for public water supply systems, to suggest limiting values for items upon which an evaluation of such plans and specifications may be made by the reviewing authority, and to establish, as far as practicable, uniformity of practice.

The terms **shall** and **must** are used where practice is sufficiently standardized to permit specific delineation of requirements or where safeguarding of the public health justifies such definite action. These mandatory items serve as a checklist for the reviewing authority. The terms **should**, recommended, and preferred are used to indicate desirable procedures or methods. These non-mandatory items serve as guidelines for designers.

The term "reviewing authority" as used in these standards refers to the Montana Department of Environmental Quality or its authorized agents.

It is not possible to cover recently developed processes and equipment in a publication of this type. However, the policy is to encourage, rather than obstruct, the development of new processes and equipment. Recent developments may be acceptable if they meet at least one of the following conditions: 1) have been thoroughly tested in full scale comparable installations under competent supervision; 2) have been thoroughly tested as a pilot plant operated for a sufficient time to indicate satisfactory performance; or 3) a performance bond or other acceptable arrangement has been made so the owners or official custodians are adequately protected financially or otherwise in case of failure of the process or equipment.

These standards are based on the "Recommended Standards for Water Works"(1982 Edition), prepared by the Great Lakes Upper Mississippi River Board of State Sanitary Engineers. The Board of Environmental Review acknowledges this basis and expresses its appreciation to the Great Lakes Upper Mississippi River Board of State Sanitary Engineers for its contribution to public health.

POLICY STATEMENT ON
PACKAGE WATER TREATMENT PLANTS FOR PUBLIC WATER SUPPLIES

Pre-engineered water treatment plants are becoming available and being used for production of potable water at public water systems. Many applications being proposed are for small systems that have relatively clean surface water sources and that are now being required to provide filtration under the federal Safe Drinking Water Act.

Pre-engineered water treatment plants are normally modular process units, which are pre-designed for specific process applications and flow rates and purchased as a package. Multiple units may be installed in parallel to accommodate larger flows.

Pre-engineered treatment plants have numerous applications but are especially applicable at small systems where conventional treatment may not be cost effective. As with any design the proposed treatment must fit the situation and assure a continuous supply of safe drinking water for water consumers. The reviewing authority may accept proposals for pre-engineered water treatment plants on a case-by-case basis where they have been demonstrated to be effective in treating the source water being used.

Factors to be considered include:

1. Raw water quality characteristics under normal and worst case conditions. Seasonal fluctuations must be evaluated and considered in the design.

2. Demonstration of treatment effectiveness under all raw water conditions and system flow demands. This demonstration may be on-site pilot or full scale testing or testing off-site where the source water is of similar quality. On-site testing is required at sites having questionable water quality or applicability of the treatment process. The proposed demonstration project must be approved by the reviewing authority prior to starting.

3. Sophistication of equipment. The reliability and experience record of the proposed treatment equipment and controls must be evaluated.

4. Unit process flexibility allowing for optimization of treatment.

5. Operational oversight that is necessary. At surface water sources full-time operators are necessary, except where the reviewing authority has approved an automation plan. See Policy Statement on Automated/Unattended Operation of Surface Water Treatment Plants.

6. Third party certification or approvals such as National Sanitation Foundation (NSF), for treatment equipment and materials that will be in contact with the water.

7. Suitable pretreatment based on raw water quality and the pilot study or other demonstration of treatment effectiveness.

8. Factory testing of controls and process equipment prior to shipment.

9. Automated troubleshooting capability built into the control system.

10. Start-up and follow-up training and troubleshooting to be provided by the manufacturer or contractor.

11. Operation and maintenance manual. This manual must provide a description of the treatment, control and pumping equipment, necessary maintenance and maintenance schedule, and a troubleshooting guide for typical problems.

12. On-site and contractual laboratory capability. The on-site testing must include all required continuous and daily testing as specified by the reviewing authority. Contract testing may be considered for other parameters.

13. Manufacturer's warranty and replacement guarantee. Appropriate safeguards for water supplier must be included in contract documents. The reviewing authority may consider interim or conditional project approvals for innovative technology when there is sufficient demonstration of treatment effectiveness and contract provisions to protect the water supplier should the treatment not perform as claimed.

14. Water supplier revenue and budget for continuing operations, maintenance and equipment replacement in the future.

Additional information on this topic is given in the "State Alternative Technology Approval Protocol," dated June 1996, which was developed by the Association of State Drinking water Administrators, U.S. Environmental Protection Agency and various industry groups.

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers, 1997.

POLICY STATEMENT ON
REVERSE OSMOSIS (RO)
FOR PUBLIC WATER SUPPLIES

Reverse osmosis is a physical process in which suitably pretreated water is delivered at high pressure against a semi permeable membrane. The membrane rejects most solute ions and molecules, while allowing water of very low mineral content to pass through. The process produces a reject concentrate waste stream in addition to the clear permeate product. Reverse osmosis systems have been successfully applied to saline ground waters, brackish waters, and seawater.

The following items should be considered in evaluating the applicability of reverse osmosis:

1. Membrane Selection: Two types of membranes are typically used. These are Cellulose Acetate and Polyamide/Composite. Membrane configurations include tubular, spiral wound and hollow fine fiber. Operational conditions and useful life vary depending on type of membrane selected.

2. Useful Life of the Membrane: The membrane represents a major cost component in the overall water system. Membrane replacement frequency can significantly affect the overall cost of operating the treatment facility.

3. Pretreatment Requirements: Acceptable feed water characteristics are dependent on the type of membrane and operational parameters of the system. Without pretreatment, the membrane may become severely fouled resulting in a severely shortened useful life. Pretreatment may be needed for turbidity reduction, iron or manganese removal, stabilization of the water to prevent scale formation, microbial control, chlorine removal, dissolved solids reduction, pH adjustment or hardness reduction.

4. Treatment Efficiency: Reverse osmosis is highly efficient in removing metallic salts and ions from the raw water. Efficiencies, however, do vary depending on the ion being removed and the membrane utilized. For most commonly encountered ions, removal efficiencies will range from 85% to over 99%. Organics removal is dependent on the molecular weight, the shape of the organic molecule and the pore size of the membrane utilized. Removal efficiencies may range from as high as 99% to less than 30%.

5. Bypass Water: Reverse osmosis permeate will be virtually demineralized. The design should provide for a portion of the raw water to bypass the unit to maintain stable water within the distribution system.

6. Post Treatment: Post treatment typically includes degasification for carbon dioxide and hydrogen sulfide removal (if present), pH adjustment for corrosion control and chlorination.

7. Reject Water: Reject water may range from 25% to 50% of the raw water pumped to the reverse osmosis unit. This may present a problem both from the standpoint of source availability and from the standpoint of waste treatment capabilities. The amount of reject water from a unit may be reduced to a limited extent by increasing the feed pressure to the unit; however, this may result in a shorter membrane life. Acceptable methods of waste disposal include discharge to the municipal sewer system or to an evaporation pond.

8. Cleaning the Membrane: The osmosis membrane must be periodically replaced or cleaned with acid. Method of cleaning and chemicals used must be approved by the state, reviewing agency. Care must be taken in the acid cleaning process to prevent contamination of both the raw and finished water system.

9. Pilot Plant Study: Prior to initiating the design of a reverse osmosis treatment facility, the state-reviewing agency should be contacted to determine if a pilot plant study would be required. In most cases, a pilot plant study will be required to determine the best membrane to use, the type of pretreatment, type of post treatment, the bypass ratio, the amount of reject water, process efficiency and other design criteria.

10. Operator Training and Startup: The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training must be provided prior to plant start-up.

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers, 1997.

POLICY ON AUTOMATED/UNATTENDED OPERATION OF SURFACE WATER TREATMENT PLANTS.

Recent advances in computer technology, equipment controls and Supervisory Control and Data Acquisition (SCADA) Systems have brought automated and off-site operation of surface water treatment plants into the realm of feasibility. Coincidentally, this comes at a time when renewed concern for microbiological contamination is driving optimization of surface water treatment plant facilities and operations and finished water treatment goals are being lowered to levels of < 0.1 NTU turbidity and < 20 total particle counts per milliliter.

The reviewing authority encourages any measures, including automation, that assist operators in improving plant operations and surveillance functions.

Automation of surface water treatment facilities to allow unattended operation and off-site control presents a number of management and technological challenges, which must be overcome before an approval, can be considered. Each facet of the plant facilities and operations must be fully evaluated to determine what on-line monitoring is appropriate, what alarm capabilities must be incorporated into the design and what staffing is necessary. Consideration must be given to the consequences and operational response to treatment challenges, equipment failure and loss of communications or power.

An engineering report must be developed as the first step in the process leading to design of the automation system. The engineering report to be submitted to review authorities must cover all aspects of the treatment plant and automation system including the following information/criteria:

1. Identify all critical features in the pumping and treatment facilities that will be electronically monitored, have alarms and can be operated automatically or off-site via the control system. Include a description of automatic plant shutdown controls with alarms and conditions, which would trigger shutdowns. Dual or secondary alarms may be necessary for certain critical functions.

2. Automated monitoring of all critical functions with major and minor alarm features must be provided. Automated plant shutdown is required on all major alarms. Automated startup of the plant is prohibited after shutdown due to a major alarm. The control system must have response and adjustment capability on all minor alarms. Built-in control system challenge test capability must be provided to verify operational status of major and minor alarms.

3. The plant control system must have the capability for manual operation of all treatment plant equipment and process functions.

4. A plant flow diagram that shows the location of all critical features, alarms and automated controls to be provided.

5. A description of off-site control station(s) that allow observation of plant operations, that receive alarms and that have the ability to adjust and control operation of equipment and the treatment process.

6. A certified operator must be on "standby duty" status at all times with remote operational capability and must be located within a reasonable response time of the treatment plant.

7. A certified operator must conduct an on-site check at least once per day to verify proper operation and plant security.

8. Description of operator staffing and training planned or completed in both process control and the automation system.

9. Operations manual, which gives operators, step-by-step procedures for understanding and using the automated control system under all water quality conditions. Emergency operations during the power or communication failures or other emergencies must be included.

10. A plan for a 6 month or greater demonstration period to prove the reliability of producers, equipment and surveillance system. A certified operator must be on-duty during the demonstration period. The final plan must identify and address any problems and alarms that occurred during the demonstration period. Challenge testing of each critical component of the overall system must be included as part of the demonstration project.

11. Schedule for maintenance of equipment and critical parts replacement.

12. Sufficient finished water storage must be provided to meet system demands and CT requirements whenever normal treatment production is interrupted as the result of automation system failure or plant shutdown.

13. Sufficient staffing must be provided to carry out daily on-site evaluations, operational functions and needed maintenance and calibration of all critical treatment components and monitoring equipment to ensure reliability of operations.

14. Plant staff must perform, at a minimum, weekly checks on the communication and control system to ensure reliability of operations. Challenge testing of such equipment should be part of normal maintenance routines.

15. Provisions must be made to ensure security of the treatment facilities at all times. Appropriate intrusion alarms must be provided so that alarms are effectively communicated to the operator in charge.

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers, 1997.

POLICY STATEMENT ON BAG AND CARTRIDGE FILTERS FOR PUBLIC WATER SUPPLIES

Bag and cartridge technology has been used for some time in foods, pharmaceutical and industrial applications. This technology is increasingly being used by small public water supplies for treatment of drinking water. A number of states have accepted bag and cartridge technology as an alternate technology for compliance with the filtration requirements of the Surface Water Treatment Rule.

The particulate loading capacity of these filters is low, and, once expended, the bag or cartridge filter must be discarded. This technology is designed to meet the low flow requirement needs of small systems. The operational and maintenance cost of bag and cartridge replacement must be considered when designing a system. These filters can effectively remove particles from water in the size range of Giardia cysts (5-10 microns) and Cryptosporidium (2-5 microns).

Presently, filtration evaluation is based on Giardia cyst removal. However, consideration should be given to the bag or cartridge filter's ability to remove particles in the size range of Cryptosporidium because this is a current public health concern.

With this type of treatment there is no alteration of water chemistry. So, once the technology has demonstrated the 2-log removal efficiency, no further pilot demonstration is necessary. The demonstration of filtration is specific to a specific housing and a specific bag or cartridge filter. Any other combinations of different bags, cartridges, or housings will require additional demonstration of filter efficiency.

Treatment of surface water should include source water protection, filtration, and disinfection.

The following items should be considered in evaluating the applicability of bag cartridge filtration.

Pre-design/Design

1. The filter housing and bag/cartridge filter must demonstrate a filter efficiency of 2-log reduction in particles size 2 microns and above. The reviewing authority will decide whether or not a pilot demonstration is necessary for each installation. This filtration efficiency may be accomplished by:

    a. Microscopic particulate analysis, including particle counting, sizing and identification, which determines occurrence and removals of micro-organisms and other particles across a filter or system under ambient raw water source conditions, or when artificially challenged.

b. Giardia/Cryptosporidium surrogate particle removal evaluation in accordance with procedures specified in NSF Standard 53 or equivalent procedures. These evaluations may be conducted by NSF or by another third-party whose certification would be acceptable to the reviewing authority.

c. "Particle Size Analysis Demonstration for Giardia Cyst Removal Credit" procedure presented in Appendix M of the EPA "Surface Water Treatment Rule Guidance Manuel."

d. "Nonconsensus" live Giardia challenge studies that have been designed and carried out by a third-party agent recognized and accepted by the reviewing authority for interim evaluations. Presently, uniform protocol procedures have not been established for live Giardia challenge studies. If a live Giardia challenge study is performed on site there must be proper cross-connection control equipment in place and the test portion must be operated to waste.

e. Methods other than these that have been approved by the reviewing authority.

2. System components such as housing, bags, cartridges, membranes, gaskets, and O-rings should be evaluated under NSF Standard 61, or an equivalent method, for leaching of contaminants. The reviewing authority may require additional testing.

3. The source water or pre-treated water should have a turbidity of less than 5 NTU.

4. It is recommended that the flow rate through the treatment process be monitored. The flow rate through the bag/cartridge filter must not exceed 20 gpm, unless documentation at higher flow rates demonstrates that it will meet the requirements for removal of particles.

5. Pretreatment is strongly recommended (if not required by the reviewing authority). This is to provide a more constant water quality to the bag/cartridge filter. Examples of pretreatment include media filters, larger opening bag/cartridge filters, infiltration galleries, and beach wells. Location of the water intake should be considered in the pretreatment evaluation.

6. Particle count analysis may be used to determine the level of pretreatment that should be provided. It should be noted that particulate counting is a "snap shot" in time and that there can be seasonal variations such as algae blooms, lake turnover, spring runoff and heavy rainfall events that will give varied water quality.

7. It is recommended that chlorine or another disinfectant be added at the head of the treatment process to reduce/eliminate the growth of algae, bacteria, etc., on the filters. The impact on disinfection-byproduct formation should be considered.

8. A filter to waste component is strongly recommended (if not required by the reviewing authority) for any pretreatment pressure sand filters. At the beginning of each filter cycle and/or after every backwash of the prefilters a set amount of water should be discharged to waste before water flows into the bag/cartridge filter.

9. If pressure media filters are used for pretreatment they must be designed according to Section 4.2 2.

10. A sampling tap must be provided ahead of any treatment so a source water sample can be collected.

11. Pressure gages and sampling taps must be installed before and after the media filter and before and after the bag/cartridge filter.

12. An automatic air release valve must be installed on top of the filter housing.

13. Frequent start and stop operation of the bag or cartridge filter should be avoided. To avoid this frequent start and stop cycle the following options are recommended.

    a. install a slow opening and closing valve ahead of the filter to reduce flow surges

    b. reduce the flow through the bag or cartridge filter to as low as possible to lengthen filter run times.

    c. install a re-circulating pump that pumps treated water back to a point ahead of the bag or cartridge filter. Care must be taken to make sure there is no cross connection between the finished water and raw water.

14. A minimum of two bags or cartridge filter housings should be provided for water systems that must provide water continuously.

15. A pressure relief valve should be incorporated into the bag or cartridge filter housing.

16. Complete automation of the treatment system is not required. Automation of the treatment plant should be incorporated into the ability of the water system to monitor the finished water quality. It is important that a qualified water operator is available to run the treatment plant.

17. A plan of action should be in place should the water quality parameters fail to meet EPA or the local reviewing authority's standards.

Operations

1. The filtration and backwash rates must be monitored so that the prefilters are being optimally used.

2. The bag and cartridge filters must be replaced when a pressure difference of 30 psi or other pressure difference recommended by the manufacturer is observed. It should be noted that bag

filters do not load linearly. Additional observation of the filter performance is required near the end of the filter run.

3. Maintenance must be performed in accordance with the manufacturer's recommendations.

4. The following parameters should be monitored:

    a. Flow rate, instantaneous
    b. Flow rate, total
    c. Operating pressure
    d. Pressure differential
    e. Turbidity

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Work

POLICY STATEMENT ON USE OF CHLORAMINE DISINFECTANT FOR PUBLIC WATER SUPPLIES

Ammonia can be used to convert chlorine in drinking water into the longer lasting but less powerful disinfectant chloramine. Possible advantages and disadvantages of the use of chloramine rather than free chlorine include:

> Use of chloramine may reduce total trihalomethane concentrations reaching consumers. This is because chloramine does not form trihalomethanes on contact with natural organic matter in the water, although it may form other by-products.
>
> Use of chloramine may reduce the need for high disinfectant concentrations to be added at the plant and/or at booster stations. This can be an advantage during the warmer seasons of the year for protection of the water and mains system, from bacterial overgrowth. Although they may contribute to other problems, the lowered disinfectant requirements also can reduce complaints due to unacceptable chlorine taste/odor problems from consumers located close to water plants.
>
> The use of chloramine may provide less protection from contamination of the distribution system through cross connections, water main breaks and other causes.

Unlike most substances added to water for treatment purposes, chloramine cannot be prepared at high concentrations. It can be made only by adding ammonia to lightly prechlorinated water or by adding chlorine to water containing low concentrations of ammonia. Contact between high concentrations of chlorine and ammonia or ammonium salts must be avoided because the sensitive and violently explosive substance, nitrogen trichloride, may be formed.

Operating authorities who wish to modify disinfectant practices by using chloramine must show the reviewing authority clear evidence that bacteriological and chemical protection of consumers will not be compromised in any way and that aspects of chloramination mentioned below have been considered in any permit application.

1. Chloramine, which is less powerful than free chlorine, may be suitable for disinfection of some ground water supplies but it is inadequate in strength for primary disinfection of surface waters.

2. Chloramine can be suitable for protecting potable water in distribution systems against bacterial contamination. The chloramine tends to remain active for longer periods and at greater distances from the plant than free chlorine. Chloramine concentrations should be maintained higher than chlorine to avoid nitrifying bacterial activity. A range of 1-2 mg/L, measured as combined chlorine, on entry to the distribution system and greater than 1 mg/L at the system extremities is recommended. Chloramine can be less odorous than chlorine so these concentrations may be tolerated well by consumers.

3. Suitable commercial sources of ammonia for chloramine production are either ammonia gas or water solutions of ammonia or ammonium sulphate. Ammonia gas is supplied as compressed liquid in cylinders that must be stored in separate facilities designed for chlorine gas. Ammonia solutions must be stored in containment with adequate cooling to prevent gas release from storage and gas release must be handled with pressure relief systems. Absorption/neutralization systems for ammonia gas leaks/spills must be designed specially for ammonia. Ammonium sulphate is available as a free flowing powdered solid that must be stored in cool dry conditions and dissolved in water for use.

4. Thorough and reasonably rapid mixing of chlorine and ammonia in the main plant stream must be arranged to avoid formation of odorous dichloramine. Sufficient ammonia must be added to provide at least a small excess (more than one part of ammonia to 4 parts of chlorine) over that required to convert all the free chlorine present to chloramine.

5. Addition of ammonia gas or ammonia solution will increase the pH of the water and addition of ammonium sulphate depresses the pH. The actual pH shift may be small in well-buffered water but the effects on disinfectant power and corrosiveness of the water may require consideration. Ammonia gas forms alkaline solutions, which may cause local plugging by lime deposition. Where hard water is to be treated, a side stream of pre-softened water may be needed for ammonia dilution to reduce plugging problems.

6. The use of chloramine in distribution systems that are not well maintained by flushing, swabbing and other regular routine maintenance activities, can lead to local loss of disinfectant residual, nitrifying bacterial activity and, possibly, over a period of time, to persistent high coliform bacterial counts, which may not respond to reversion to the use of free chlorine. Early detection of nitrifying bacteria activity may be made by checking for reduced dissolved oxygen and elevated nitrite levels.

7. Chloramine in water is considerably more toxic than free chlorine to fish and other aquatic organisms. Consideration must therefore be given to the potential for leaks to contaminate and damage natural watercourse ecosystems. Kidney dialysis treatment can be upset by use of chloraminated water. Medical authorities, hospitals and commercial and domestic aquarium keepers should be notified so they can arrange for precautions to be taken.

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Health & Environmental Managers, 1997.

POLICY STATEMENT ON MEMBRANE FILTRATION FOR TREATING SURFACE SOURCES

Low pressure membrane filtration technology has emerged as a viable option for addressing current and future drinking water regulations related to treatment of surface water sources. Recent research and applied full-scale facilities have demonstrated the efficient performance of both Microfiltration (MF) and Ultrafiltration (UF) as feasible treatment alternatives to traditional granular media processes. Both MF and UF have been shown to be effective in removing identified parameters in the Surface Water Treatment Rule (for example, Giardia/Cryptosporidium, bacteria, turbidity and possibly viruses). The following provides a brief description of the characteristics of each process as well as selection and design considerations.

Characteristics: MF and UF membranes are most commonly made from organic polymers (for example, cellulose acetate, polysulfones, polyamides, polypropylene or polycarbonates). The physical configurations include hollow-fiber, spiral wound and tubular. MF membranes are capable of removing particles with sizes down to 0.1-0.2 microns. UF processes have a probable lower cutoff rating of .005-01 microns.

Typical flux (rate of finished water permeate per unit membrane surface area) at 20 degrees C for MF ranges between 50-100 gallons/sq.ft./day (gsfd), whereas, the typical UF flux range is 10-50 gsfd. Required operating pressures range from 5-10 psi for MF and 15-70 psi for UF.

Because both processes have relatively small membrane pore diameters, membrane fouling, caused by organic and inorganic, as well as physical, contaminants, is expected. Periodic flushing and cleaning is employed once a targeted transmembrane pressure differential has been reached. Typical cleaning agents include acids, bases, surfactants, enzymes and certain oxidants, depending upon membrane material and foulants encountered.

Overall treatment requirements and disinfection credits must be discussed with and approved by the reviewing authority. Disinfection is required with membrane filtration.

Selection and Design Considerations:

1. A review of historical source raw water quality data, including turbidity and/or particle counts, organic loading, temperature differentials, as well as other inorganic and physical parameters, can indicate whether either process is feasible. The degree of pre-treatment, if any, can also be ascertained. Design considerations and membrane selection at this phase must also address the issue of target removal efficiencies versus acceptable trans-membrane pressure differentials.

2. The useful life expectancy of a particular membrane under consideration should be evaluated. Membrane replacement frequency is a significant factor in operation and maintenance cost comparisons in the selection of the process.

3. Many membrane materials are incompatible with certain oxidants. If the system must rely on pretreatment oxidants for other purposes (for example, zebra mussel control, taste and odor control), the selection of the membrane material becomes a significant design consideration.

4. The source water temperature can significantly impact the flux of the membrane under consideration. At low water temperatures the flux can be reduced appreciably, possibly impacting process feasibility or the number of membrane units required for a full-scale facility.

5. Flushing volumes can range from 5-25 percent of the permeate flow, depending upon the frequency of flushing/cleaning and the degree of fouling; and flushing volume is an important

factor in specifying the number of treatment units required.

6. An appropriate level of finished water monitoring should be provided to routinely evaluate membrane and housing integrity and overall filtration performance. Monitoring options may include particle counters, manual and/or automated pressure testing or air diffusion testing.

7. Cross connection considerations are necessary, particularly regarding chemical feeds used for membrane cleaning.

8. Redundancy of critical control components must be considered in the final design.

9. Other post-membrane treatment requirements must be evaluated in the final design to address other contaminants of concern such as color and disinfection by-product precursors.

10. Prior to initiating the design of a membrane treatment facility, the state reviewing authority should be contacted to determine if a pilot plant study will be required. In most cases, a pilot plant study will be necessary to determine the best membrane to use, particulate/organism removal efficiencies, cold and warm water flux, the need for pre-treatment, fouling potential, operating and transmembrane pressure and other design considerations. Any virus removal credit must also be documented through an appropriate piloting process. The state reviewing authority should be contacted prior to conducting the pilot study to establish the protocol to be followed.

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Health & Environmental Managers, 1997.

POLICY STATEMENT ON OZONATION FOR PUBLIC WATER SUPPLIES

Ozonation systems are generally used for disinfection, oxidation and microflocculation. When applied, all of these reactions may occur but typically only one is the primary purpose for its use. The other reactions would become secondary benefits of the installation.

Effective disinfection occurs as demonstrated by the fact that the "CT" values for ozone, for inactivation of viruses and Giardia cysts, are considerably lower than the "CT" values for other disinfectants. Also, recent research indicates that ozone can be an effective disinfectant for the maturation of cryptosporidium. Microflocculation and enhanced filterability has been demonstrated for many water supplies but has not occurred in all waters. Oxidation of organic compounds such as color, taste and odor, and detergents and inorganic compounds such as iron, manganese, heavy metals and hydrogen sulfide has been documented. The chemical interaction of ozone with organic components, however, may result in an undesirable increase in the level of assimilable organic carbon (AOC) and THM precursors and, therefore, should be an initial process selection consideration. The effectiveness of oxidation has been varied, depending on pH and alkalinity of the water. These parameters affect the formation of highly reactive hydroxyl radicals, or, conversely, the scavenging of this oxidant. High levels of hydroxyl radicals, cause lower levels of residual ozone. Depending on the desired oxidation reaction, it may be necessary to maximize ozone residual or maximize hydroxyl radical formation. For disinfection, residual ozone is necessary for development of "CT"

As a minimum, bench scale studies must be conducted to determine minimum and maximum ozone dosages for disinfection "CT" compliance and oxidation reactions. More involved pilot studies must be conducted when necessary to document benefits and THM pre-cursor removal effectiveness. Consideration must be given to multiple points of ozone addition. Pilot studies must be conducted for all surface waters. Extreme care must be taken during bench and pilot scale studies to ensure accurate results. Particularly sensitive measurements include gas flow rate, water flow rate, and ozone concentration.

Following the use of ozone, the application of a disinfectant that maintains a measurable residual will be required in order to ensure a bacteriologically safe water is carried throughout the distribution system.

Furthermore, because of the more sophisticated nature of the ozone process, a higher degree of operator maintenance skills and training is required. The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training must be provided prior to plant startup.

The following items must be addressed in the design:

1. Feed Gas Preparation

a. General

Feed gas can be air, high purity oxygen, or oxygen enriched air. Air handling equipment of conventional low pressure air feed systems must consist of an air compressor, water, air separator, refrigerant dryer, heat reactivated desiccant dryer, and particulate filters. Some "package" ozonation systems for small plants may work effectively operating at high pressure without the refrigerant dryer and with a "heat-less" desiccant dryer. In all cases the design engineer must ensure that the maximum dew point of -60°C (-76°F) will not be exceeded at any time. For oxygen-feed systems, dryers typically are not required.

b. Air Compression

(1) Air compressors must be of the liquid-ring or rotary lobe, oil-less, positive displacement type for smaller systems. Dry rotary screw compressors must be used for larger systems.

(2) The air compressor must have the capacity to simultaneously provide for maximum ozone demand, provide the air-flow required for purging the desiccant dryers (where required) and allow for standby capacity.

(3) Air feed for the compressor must be drawn from a point protected from rain, condensation, mist, fog and contaminated air sources to minimize the moisture and hydrocarbon content of the air supply.

(4) A compressed air after-cooler and/or entrainment separator with automatic drain must be provided prior to the dryers to reduce the water vapor.

(5) A back-up air compressor must be provided so that ozone generation is not interrupted in the event of a breakdown.

c. Air Drying

(1) Dry, dust-free and oil-free gas must be provided to the ozone generator. Dry gas is essential to prevent formation of nitric acid, to increase the efficiency of ozone generation and to prevent damage to the generator dielectrics. Sufficient drying to a maximum dew point of -60°C (-76°F) must be provided at the end of the drying cycle.

(2) Drying for high-pressure systems can be accomplished using heatless desiccant dryers only. For low-pressure systems, a refrigeration air dryer in series with heat-reactivated desiccant dryers must be used.

(3) A refrigeration dryer capable of reducing inlet air temperature to 4°C (40°F) must be provided for low-pressure air preparation systems. The dryer can be of the compressed refrigerant type or chilled water type.

(4) For heat-reactivated desiccant dryers, the unit must contain two desiccant filled towers complete with pressure relief valves, two four-way valves and a heater. Also, external type dryers must have a cooler unit and blowers. The size of the unit must be such that the specified dew point will be achieved during a minimum adsorption cycle time of 16 hours while operating at the maximum expected moisture loading conditions.

(5) Multiple air dryers must be provided so that the ozone generation is not interrupted in the event of dryer breakdown.

(6) Each dryer must be capable of venting "dry" gas to the atmosphere, prior to the ozone generator, to allow start-up when other dryers are "on-line".

d. Air Filters

(1) Air filters must be provided on the suction side of the air compressors, between the air compressors and the dryers and between the dryers and the ozone generators.

(2) The filter before the desiccant dryers must be of the coalescing type and be capable of removing aerosol and particulates larger than 0.3 microns in diameter. The filter after the

desiccant dryers must be of the particulate type and be capable of removing all particulates greater than 0.1 microns in diameter, or smaller if specified by the generator manufacturer.

e. Air Preparation Piping

Piping in the air preparation system may be common grade steel seamless copper, stainless steel or galvanized steel. The piping must be designed to withstand the maximum pressures in the air preparation system.

2. Ozone Generator

a. Capacity

(1) The production rating of the ozone generators must be stated in pounds per day and kW-h per pound at a maximum cooling water temperature and maximum ozone concentration.

(2) The design must ensure that the minimum concentration of ozone in the generator exit gas will not be less than 1 percent (by weight).

(3) Generators must be sized to have sufficient reserve capacity so that the system does not operate at peak capacity for extended periods of time, which can result in premature breakdown of the dielectrics.

(4) The production rate of ozone generators will decrease as the temperature of the coolant increases. If there is to be a variation in the supply temperature of the coolant throughout the year, curves or other data must be used to determine production changes due to the temperature change of the supplied coolant. The design must ensure that the generators can produce the required ozone at maximum coolant temperature.

(5) Appropriate ozone generator backup equipment must be provided.

b. Electrical

The generators may be low, medium or high frequency type. Specifications must require that the transformers, electronic circuitry and other electrical hardware be proven, high quality components designed for ozone service.

c. Cooling

The required water flow to an ozone generator varies with the ozone production. Normally, unit design provides a maximum cooling water temperature rise of 2.8°C (5°F). The cooling water must be properly treated to minimize corrosion, scaling and microbiological fouling of the waterside of the tubes. A closed loop cooling water system is often used to ensure that proper water conditions are maintained. Where cooling water is treated cross connection control must be provided to prevent contamination of the potable water supply in accordance with Section 8.8.2.

d. Materials

To prevent corrosion, the ozone generator shell and tubes must be constructed of Type 316L stainless steel.

3. Ozone Contactors

The selection or design of the contactor and method of ozone application depends on the purpose for which the ozone is being used.

a. Bubble Diffusers

(1) Where disinfection is the primary application a minimum of two contact chambers, each equipped with baffles to prevent short-circuiting and induce countercurrent flow, must be provided. Ozone must be applied using porous-tube or dome diffusers.

(2) The minimum contact time must be 10 minutes, the reviewing authority, if justified by appropriate design and “CT” considerations may approve a shorter contact time.

(3) For ozone applications in which precipitates are formed, such as with iron and manganese removal, porous diffusers should be used with caution.

(4) Where taste and odor control is of concern, multiple application points and contactors must be considered.

(5) Contactors should be separate closed vessels that have no common walls with adjacent rooms. The contactor must be kept under negative pressure and sufficient ozone monitors must be provided to protect worker safety. Placement of the contactor where the entire roof is exposed to the open atmosphere is recommended. In no case must the contactor roof be a common wall with a separate room above the contactor.

(6) Large contact vessels should be made of reinforced concrete. All reinforcement bars must be covered with a minimum of 1.5 inches of concrete. Smaller contact vessels may be made of stainless steel, fiberglass or other material which will be stable in the presence of residual ozone and ozone in the gas phase above the water level.

(7) Where necessary a system must be provided between the contactor and the off-gas destruct unit to remove froth from the air and return the other to the contactor or other location acceptable to the reviewing authority. If foaming is expected to be excessive, a potable water spray system must be placed in the contactor headspace.

(8) All openings into the contactor for pipe connections, hatchways, etc., must be properly sealed using welds or ozone resistant gaskets such as Teflon or Hypalon.

(9) Multiple sampling ports must be provided to enable sampling of each compartment's effluent water and to confirm "CT" calculations.

(10) A pressure/vacuum relief valve must be provided in the contactor and piped to a location where there will be no damage to the destruction unit.

(11) The diffusion system should work on a countercurrent basis such that the ozone is fed at the bottom of the vessel and water is fed at the top of the vessel.

(12) The depth of water in bubble diffuser contactors should be a minimum of 18 feet. The contactor should also have a minimum of 3 feet of freeboard to allow for foaming.

(13) All contactors must have provisions for cleaning, maintenance and drainage of the contactor. Each contactor compartment must also be equipped with an access hatchway.

(14) Aeration diffusers must be fully serviceable by either cleaning or replacement.

b. Other contactors

Other contactors, such as the venturi or aspirating turbine mixer contactor, may be approved by the reviewing authority provided adequate ozone transfer is achieved and the required contact times and residuals can be met and verified.

4. Ozone Destruction Unit

a. To meet safety and air quality standards, a system for treating the final off-gas from each contactor must be provided. Acceptable systems include thermal destruction and thermal/catalytic destruction units.

b. To reduce the risk of fires, the use of units that operate at lower temperatures is encouraged, especially where high purity oxygen is the feed gas.

c. The maximum allowable ozone concentration in the discharge is 0.1 p.m. (by volume).

d. At least two units must be provided which are each capable of handling the entire gas flow.

e. Exhaust blowers must be provided to draw off-gas from the contactor into the destruct unit.

f. Catalysts must be protected from froth, moisture and other impurities, which may harm the catalyst.

g. The catalyst and heating elements must be located where they can easily be reached for maintenance.

5. Piping Materials

Only low carbon 304L and 316L stainless steels may be used for ozone service with 316L the preferred.

6. Joints and Connections

a. Connections on piping used for ozone service must be welded where possible.

b. Connections with meters, valves or other equipment must be made with flanged joints with ozone resistant gaskets, such as Teflon or Hypalon. Screwed fittings may not be used because of their tendency to leak.

c. A positive closing plug or butterfly valve plus a leak-proof check valve must be provided in the piping between the generator and the contactor to prevent moisture reaching the generator.

7. Instrumentation

a. Pressure gauges must be provided at the discharge from the air compressor, at the inlet to the refrigeration dryers, at the inlet and outlet of the desiccant dryers, at the inlet to the ozone generators and contactors and at the inlet to the ozone destruction unit.

b. Electric power meters should be provided for measuring the electric power supplied to the ozone generators. Each generator must have a trip, which shuts down the generator when the wattage exceeds a certain preset level.

c. Dew point monitors must be provided for measuring the moisture of the feed gas from the desiccant dryers. Because it is critical to maintain the specified dew point, it is recommended that continuous recording charts be used for dew point monitoring which will allow for proper adjustment of the dryer cycle. Where there is potential for moisture entering the ozone generator from downstream of the unit or where moisture accumulation can occur in the generator during shutdown, post-generator dew point monitors must be used.

d. Air flow meters must be provided for measuring air flow from the desiccant dryers to each of the other ozone generators, air flow to each contactor and purge air flow to the desiccant dryers.

e. Temperature gauges must be provided for the inlet and outlet of the ozone cooling water and the inlet and outlet of the ozone generator feed gas, and, if necessary, for the inlet and outlet of the ozone power supply cooling water.

f. Water flow meters must be installed to monitor the flow of cooling water to the ozone generators and, if necessary, to the ozone power supply.

g. Ozone monitors must be installed to measure zone concentration in both the feed-gas and off-gas from the contactor and in the off-gas from the destruct unit. For disinfection systems, monitors must also be provided for monitoring ozone residuals in the water. The number and location of ozone residual monitors must be such that the amount of time that the water is in contact with the ozone residual can be determined.

h. At least one ambient ozone monitor must be installed in the vicinity of the contactor and at least one must be installed in the vicinity of the generator. Ozone monitors must also be installed in any areas where ozone gas may accumulate.

8. Alarms

The following alarm/shutdown systems should be considered at each installation:

a. Dew point shutdown/alarm - This system should shut down the generator in the event that the system dew point exceeds -60°C (-76°F).

b. Ozone generator cooling water flow shutdown/alarm - This system should shut down the generator in the event that cooling water flow decreases to the point that generator damage could occur.

c. Ozone power supply cooling water flow shutdown/alarm - This system should shut down the power supply in the event that cooling water flow decreases to the point that damage could occur to the power supply.

d. Ozone generator cooling water temperature shutdown/alarm - This system should shut down the generator if either the inlet or outlet cooling water exceeds a certain preset temperature.

e. Ozone power supply cooling water temperature shutdown/alarm - This system should shut down the power supply if either the inlet or outlet cooling water exceeds a certain preset temperature.

f. Ozone generator inlet feed-gas temperature shutdown/alarm - This system should shut down the generator if the feed-gas temperature is above a preset value.

g. Ambient ozone concentration shutdown/alarm - The alarm should sound when the ozone level in the ambient air exceeds 0.1 ppm. or a lower value chosen by the water supplier. Ozone generator shutdown should occur when ambient ozone levels exceed 0.3 ppm. (or a lower value) in either the vicinity of the ozone generator or the contactor.

h. Ozone destruct temperature alarm - The alarm should sound when temperature exceeds a preset value.

9. Safety

a. The maximum allowable ozone concentration in the air to which workers may be exposed may not exceed 0.1 ppm. (by volume).

b. Noise levels resulting from the operating equipment of the ozonation system must be controlled to within acceptable limits by special room construction and equipment isolation.

c. High voltage and high frequency electrical equipment must meet current electrical and fire codes.

d. Emergency exhaust fans must be provided in the rooms containing the ozone generators to remove ozone gas if leakage occurs.

e. A portable purge air blower that will remove residual ozone in the contactor prior to entry for repair or maintenance should be provided.

10. Construction Considerations

a. Prior to connecting the piping from the desiccant dryers to the ozone generators the air compressors should be used to blow the dust out of the desiccant.

b. The contactor should be tested for leakage after sealing the exterior, this can be done by pressurizing the contactor and checking for pressure losses.

c. Connections on the ozone service line should be tested for leakage using the soap-test method.

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Health & Environmental Managers, 1997.

INTERIM STANDARD NITRATE REMOVAL USING SULFATE SELECTIVE ANION EXCHANGE RESIN

Four treatment processes are generally considered acceptable for nitrate/nitrite removal. These are anion exchange, reverse osmosis, nanofiltration and electrodialysis. Although these treatment processes, when properly designed and operated, will reduce the nitrate/nitrite concentration of the water to acceptable levels, primary consideration must be given to reducing the nitrate/nitrite levels of the raw water through either obtaining water from an alternate water source or through watershed management. Reverse osmosis nanofiltration or electrodialysis should be investigated when the water has high levels of sulfate or when the chloride content or dissolved solids concentration is of concern.

Most anion exchange resins used for nitrate removal are sulfate selective resins. Although nitrate selective resins are available, these resins typically have a lower total exchange capacity.

SPECIAL CAUTION

If a sulfate selective anion exchange resin is used beyond bed exhaustion, the resin will continue to remove sulfate from the water by exchanging the sulfate for previously removed nitrates resulting in treated water nitrate levels being much higher than raw water levels. Therefore, it is extremely important that the system not be operated beyond design limitations.

PRE-TREATMENT REQUIREMENTS

An evaluation must be made to determine if pretreatment of the water is required if the combination of iron, manganese, and heavy metals exceeds 0.1 milligrams per liter.

DESIGN

Anion exchange units are typically of the pressure type, down flow design. Although, a pH spike can typically be observed shortly before bed exhaustion, automatic regeneration based on volume of water treated should be used unless justification for alternate regeneration is submitted to and approved by the reviewing authority. A manual override must be provided on all automatic controls. A minimum of two units must be provided. The total treatment capacity must be capable of producing the maximum day water demand at a level below the nitrate/nitrite MCL. If a portion of the water is bypassed around the unit and blended with the treated water, the maximum blend ratio allowable must be determined based on the highest anticipated raw water nitrate level. If a bypass is provided, a totaling meter and a proportioning or regulating device or flow regulating valves must be provided on the bypass line.

EXCHANGE CAPACITY

Anion exchange media will remove both nitrates and sulfate from the water being treated. The design capacity for nitrate and sulfate removal, expressed as CaCO3, should not exceed 16,000 grains per cubic foot (37 g/l), when the resin is regenerated with 10 pounds of salt per cubic foot (160 g/l) of resin when operating at 2 to 3 gallons per minute per cubic foot (0.27 to 0.4 L /min per liter). However, if high levels of chlorides exist in the raw water, the exchange capacity of the resin should be reduced to account for the chlorides.

FLOW RATES

The treatment flow rate should not exceed 7 to 8 gallons per minute per square foot of bed area (29 to 32 cm/minute down flow rate). The back wash flow rate should be 2 to 3 gallons per minute per square foot of bed area (8 to 12 cm/minute rise rate) with a fast rinse approximately equal to the service flow rate.

FREEBOARD

Adequate freeboard must be provided to accommodate the backwash flow rate of the unit.

MISCELLANEOUS APPERTURNANCES

The system must be designed to include an adequate under drain and supporting gravel system, brine distribution equipment, and cross connection control.

MONITORING

Whenever possible, the treated water nitrate/nitrite levels should be monitored using continuous monitoring and recording equipment. The continuous monitoring equipment should be equipped with a high nitrate level alarm. If continuous monitoring and recording equipment is not provided, the finished water nitrate/nitrite levels must be determined (using a test kit) no less than daily, preferably just prior to regeneration of the unit.

WASTE DISPOSAL

Generally, waste from the anion exchange unit should be disposed in accordance with Section 4.11.2 of these Standards. However, prior to any discharge, the reviewing authority must be contacted for wastewater discharge limitations or NPDES requirements.

ADDITIONAL LIMITATIONS

Certain types of anion exchange resins can tolerate no more than, 0.05-mg/L free chlorine. When the applied water will contain a chlorine residual, the anion exchange resin must be a type that is not damaged by residual chlorine.

Source: **Recommended Standards for Water Works**, Great Lakes Upper Mississippi River Board of State Public Health & Environmental Managers, 1997.

POLICY STATEMENT ON CONTROL OF ORGANIC CONTAMINATION FOR PUBLIC WATER SUPPLIES

Although standards and advisories for organics are being developed, there have been numerous cases or organic contamination of public water supply sources. In all cases, public exposure to organic contamination must be minimized. There is insufficient experience to establish design standards, which would apply to all situations. Controlling organic contamination is an area of design that requires pilot studies and early consultation with the reviewing authority. Where treatment is proposed, best available technology must be provided to reduce organic contaminants to the lowest practical levels. Operations and monitoring must also be considered in selecting the best alternative. The following alternatives may be applicable:

1. Alternate Source Development

2. Existing Treatment Modifications

3. Air Stripping for Volatile Organics

   Consideration should be given to:

   a. materials for tower, packing and piping that are acceptable for use in contact with potable water,

   b. providing a moisture barrier (demister),

   c. metering the water flow to the tower,

   d. metering the air flow to the tower,

   e. providing influent and effluent sampling taps,

   f. disinfecting the water passing through the tower,

   g. designing the tower to reduce the critical contaminants to the lowest practical levels,

   h. the air discharge meeting the air quality standards,

   i. provisions for easy access to allow inspection, media replacement, maintenance and cleaning of the packing materials. Iron and manganese precipitation, carbonate deposition and biological fouling are potential problems,

   j. chemical stability of the finished water, and

   k. acceptable supply during periods of maintenance and operation interruptions.

   l. allow the tower to be extended in height without major reconstruction.

4. Granular Activated Carbon

   Consideration should be given to:

   a. using contact units rather than replacing a portion of existing filter media;
   b. series and parallel flow piping configurations to minimize the effect of breakthrough without reliance on continuous monitoring;

c. providing at least two units. Where only two units are provided, each must be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved rate. Where more than two units are provided, the contactors must be capable of meeting the design capacity at the approved rate with one or more (as determined in conjunction with the reviewing authority) units removed from service;

d. using virgin carbon; this is the preferred media. Although reactivated carbon may eventually present an economic advantage at large water treatment plants, such an alternative may be pursued only with the preliminary endorsement of the reviewing authority. Regenerated carbon using only carbon previously used for potable water treatment can be used for this purpose. Transportation and regeneration facilities must not have been used for carbon put to any other use;

e. acceptable means of spent carbon disposal.

Except for temporary, emergency treatment conditions, particular attention must be given to developing an engineering report, which, in addition to the normal determinations, includes the following:

1. For organic contaminants found in surface water sources:

   a. type of organic chemicals, sources, concentration, frequency of occurrence, water pollution abatement schedule, etc.,

   b. possible existing treatment plant modifications to lower organic chemical levels. Results of bench, pilot or full scale testing demonstrating treatment alternatives, effectiveness and costs,

   c. a determination of the quality and/or operational parameters which serve as the best measurement of treatment performance, and a corresponding monitoring and process control program.

2. For organic contamination found in groundwater sources:

   a. types of organic chemicals, sources, concentration, estimate of residence time within the aquifer, flow characteristics, water pollution abatement schedule, etc.,

   b. results of bench or pilot studies demonstrating treatment alternatives, effectiveness, and costs,

   c. a determination of the quality and/or operational parameters that serve as the best measure of treatment performance, and a corresponding monitoring and process control program.

The collection of this type of data is often complicated and lengthy. Permanent engineering solutions will take significant time to develop. The cost of organic analyses and the availability of acceptable laboratories may further complicate both pilot work and actual operation.

Alternative source development or purchase of water from nearby unaffected systems may be a more expedient solution for contaminated groundwater sources.

POLICY STATEMENT ON DISTRIBUTION SYSTEM CORROSION CONTROL FOR PUBLIC WATER SUPPLIES

Internal and external corrosion of a public water supply distribution system is a recognized problem that cannot be completely eliminated but can be effectively controlled. Aside from the cost of labor and materials for pipe replacement, the possible adverse health effects of corrosion products must be considered. A major corrosion failure in the distribution system mains or service connections could lead to the gross contamination of the water being delivered to the public, as well as service interruption and operation.

Control of corrosion is a function of the design, maintenance, and operation of a public water supply. These functions must be considered simultaneously in order for the corrosion control program to function properly. Corrosion problems must be solved on an individual basis depending on the materials used in the distribution system, and soil and water characteristics. Some specific information can be obtained from Section 4.8 (Stabilization) and from publications of technical societies such as the American Water Works Association, the National Association of Corrosion Engineers, and the American Society for Testing Materials. Broad areas of consideration for a corrosion control program follow.

Internal Corrosion

1. Provide for a system of records by which the nature and frequency of corrosion problems are recorded. On a plan map of the distribution system, show the location of each problem so that follow-up investigations and improvements can be made when a cluster of problems is identified.

2. When complaints are received from a customer, follow up with an inspection by experienced personnel or consultant experienced in corrosion control. Where advisable, obtain samples of water for chemical and microbiological analyses and piping and plumbing material samples. Analyses should be made to determine the type and, if possible, the cause of the corrosion.

3. Establish a program whereby a determination of the stability of the water in representative parts of the distribution system can be made. Analysis for alkalinity, pH, and corrosion products (such as lead, cadmium, copper, and iron) should be performed on water samples collected at the treatment plant or wellhead and at representative points on the distribution system. In comparing the analyses of the source water with the distribution system water, significant changes in alkalinity, pH, or corrosion products would indicate that corrosion is taking place and thereby indicate that corrective steps need to be taken.

4. Where possible, especially when corrosion has been detected in the determination of water stability, provide a program that will measure both the physical and chemical aspects of the corrosion phenomena. Physical measurement of the rate of corrosion can be made by the use of coupons, easily removed sections of pipe, connected flow-through pipe test sections, or other piping arrangements. At the same site, measure the relative degree of corrosivity on a routine basis by using corrosion indices such as the Langelier Index, Ryznar Index, or Aggressiveness Index (AWWA C400). Correlation of the data from the physical measurement, with the data from the selected corrosion index, will provide information to determine the type of corrective treatment needed and may allow for the subsequent use of the corrosion index alone to determine the degree of corrosivity in select areas of the distribution system.

5. If corrosion is found to exist throughout the distribution system, corrective measures at the treatment plant, pump station or wellhead should be initiated. A chemical feed can be made to provide a stable to slightly depositing water. In calculating the stability index and the corresponding chemical feed adjustments, consideration must be given to items such as the water temperature. If it varies with the season and within various parts of the distribution system; the velocity of flow within various parts of the distribution system; the degree of stability needed by the individual customer; and the dissolved oxygen content of distributed water, especially in waters having low hardness and alkalinity. Threshold treatment involving the feeding of a polyphosphate or a silicate to control corrosion may be considered for both ground and surface water supplies.

6. Additional control of corrosion problems can be obtained by a regulation or ordinance for the materials used in or connected to a distribution system. Careful selection of materials compatible with the physical system or the water being delivered can aid in reduction of corrosion product production.

Note: Adjustment of pH for corrosion control **must not** interfere with other pH dependent processes (e.g., color removal by alum coagulation).

External Corrosion

1. Provide for a system of records by which the nature and frequency of corrosion problems are recorded. On a plan map of the distribution system, show the location of each problem so that follow-up investigations and improvements can be made when a cluster of problems is identified.

2. If needed, perform a survey to determine the existence of facilities or installations that would provide the potential for stray, direct electric currents. Also, determine whether problems are caused by the use of water pipes as grounds for the electrical system.

3. In previously unexplored areas where aggressive soil conditions are suspect, or in areas where there are known aggressive soil conditions, perform analyses to determine the actual aggressiveness of the soil.

4. If soils are found to be aggressive, take necessary action to protect the water main, such as by encasement of the water main in polyethylene, provision of cathodic protection (in very severe instances), rerouting of water main through non-aggressive soil areas, or use of alternate, corrosion resistant water main materials.

POLICY STATEMENT ON TRIHALOMETHANE REMOVAL AND CONTROL FOR PUBLIC WATER SUPPLIES

Trihalomethanes (THMs) are formed when free chlorine reacts with organic substances, most of which occur naturally. These organic substances (called "precursors"), are a complex and variable mixture of compounds. Formation of THMs is dependent on such factors as amount and type of chlorine used, temperature, concentration of precursors, pH, and contact time. Approaches for controlling THMs include:

1. Control of precursors at the source.

    a. Selective withdrawal from reservoirs -- varying depths may contain lower concentrations of precursors at different times of the year.

    b. Plankton Control -- Algae and their by-products have been shown to act as THM precursors.

    c. Alternative sources of water may be considered, where available.

2. Removal of THM precursors and control of THM formation.

    a. Moving the point of chlorination to minimize THM formation.

    b. Removal of precursors prior to chlorination by optimizing:

        (1) Coagulation/flocculation -- sedimentation -- filtration

        (2) Precipitative softening/filtration

        (3) Direct filtration

    c Adding oxidizing agents such as potassium permanganate, ozone or chlorine dioxide to reduce or control THM formation potential.

    d. Adsorption by powdered activated carbon (PAC).

    e. Lowering the pH to inhibit the reaction rate of chlorine with precursor materials. Corrosion control may be necessary.

3. Removal of THM.

    a. Aeration - by air stripping towers.

    b. Adsorption by:

        (1) Granular Activated Carbon (GAC)

        (2) Synthetic Resins

4. Use of Alternative Disinfectants -- Disinfectants that react less with THM precursors may be used as long as bacteriological quality of the finished water is maintained. Alternative disinfectants may be less effective than free chlorine, particularly with viruses and parasites. Alternative disinfectants, when used, must be capable of providing an adequate distribution system residual. Possible health effects of by-products that may be produced by using alternative disinfectants must be taken into consideration. The following alternative disinfectants may be considered:

   a. Chlorine Dioxide

   b. Chloramines

   c. Ozone

Using various combinations of THM controls and removal techniques may be more effective than a single control or treatment method.

Any modifications to existing treatment process must be approved by the reviewing authority. Pilot plant studies are desirable.

CHAPTER 1
SUBMISSION OF PLANS

1.0 GENERAL

All reports, final plans and specifications should be submitted at least 60 days prior to the date on which action by the reviewing authority is desired. Permits for construction, for waste discharges, for stream crossings, etc., may be required from other federal, state, or local agencies. No approval for construction can be issued until final, complete, detailed plans and specifications have been submitted to the reviewing authority and found to be satisfactory. Two copies of the final plans and specifications must be submitted. An approved set will be returned to the applicant. Documents submitted for formal approval must include but not be limited to:

a. a summary of the basis of design,

b. operation requirements, where applicable,

c. general layout,

d. detailed plans,

e. specifications,

f. documentation that owner is committed to providing as-built certification of the project by a registered professional engineer.

1.1 ENGINEER'S REPORT

The engineer's report for new water works must present the following information and the engineer's report for existing water systems must, where pertinent, present the following information:

1.1.1 General information, including:

a. description of the existing water works and sewerage facilities,

b. identification of the municipality or area served,

c. name and mailing address of the owner or official custodian,

d. information requested in Appendix A for new systems.

1.1.2 Extent of water works system, including

a. description of the nature and extent of the area to be served,

b. provisions for extending the water works system to include additional areas,

c. appraisal of the future requirements for service, including existing and potential industrial, commercial, institutional, and other water supply needs.

1.1.3 Alternate plans

Where two or more solutions exist for providing public water supply facilities, each of which is feasible and practicable, discuss the alternate plans. Give reasons for selecting the one recommended, including financial considerations, and a comparison of the minimum classification of water works operator required for operation of each alternative facility.

1.1.4 (Reserved)

1.1.5 Water use data, including:

a. a description of the population trends as indicated by available records, and the estimated population which will be served by the proposed water supply system or expanded system,

b. present water consumption and the projected average and maximum daily demands, including fire flow demand (see Section 1.1.6),

c. present and/or estimated yield of the sources of supply,

d. unusual occurrences.

1.1.6 Flow requirements, including:

a. hydraulic analyses based on flow demands and pressure requirements (See Section 8.1.1),

b. fire flows, when fire protection is provided, meeting the recommendations of the State Fire Marshal, Insurance Services Office or other similar agency for the service area involved.

1.1.7 Sewage system available

Describe the existing sewage collection system and sewage treatment works, with special reference to their relationship to existing or proposed water works structures which may affect the operation of the water supply system, or which may affect the quality of the supply.

1.1.8 Sources of water supply

Describe the proposed source or sources of water supply to be developed, the reasons for their selection, and provide information as follows:

1.1.8.1 Surface water sources, including:

a. hydrological data, stream flow and weather records,

b. safe yield, including all factors that may affect it,

c. maximum flood flow, together with approval for safety features of the spillway and dam from the appropriate reviewing authority,

d. description of the watershed, noting any existing or potential sources of contamination (such as highways, railroads, chemical facilities, etc.) that may affect water quality,

e. summarized quality of the raw water with special reference to fluctuations in quality, changing meteorological conditions, etc.

f. water rights.

1.1.8.2 Groundwater sources including:

a. sites considered,

b. advantages of the site selected,

c. elevations with respect to surroundings,

d. probable character of formations through which the source is to be developed,

e. geologic conditions affecting the site, such as anticipated interference between proposed and existing wells,

f. summary of source exploration, test well depth, and method of construction; placement of liners or screen; test pumping rates and their duration; water levels and specific yield; water quality,

g. sources of possible contamination such as sewers and sewerage facilities, highways, railroads, landfills, outcroppings of consolidated water-bearing formations, chemical facilities, waste disposal wells, etc.,

h. water rights,

i. a preliminary assessment for proposed groundwater sources that may be under the direct influence of surface water, prepared in accordance with PWS-5, "Assessment of Groundwater Sources Under the Direct Influence of Surface Water,"

j. a source water protection plan prepared in accordance with PWS-6, "Source Water Protection Delineation", must be submitted for review and approval

1.1.9 Proposed treatment processes

Summarize and establish the adequacy of proposed processes and unit parameters for the treatment of the specific water under consideration. Alternative methods of water treatment and chemical use should be considered as a means of reducing waste handling and disposal problems. Pilot studies will generally be required.

1.1.10 Waste disposal

Discuss the various wastes from the water treatment plant, their volume, proposed treatment and disposal locations.

1.1.11 Automation

Provide supporting data justifying automatic equipment, including the servicing and operator training to be provided. Manual override must be provided for any automatic controls. Highly sophisticated automation may put proper maintenance beyond the capability of the plant operator, leading to equipment breakdowns or expensive servicing. Adequate funding must be assured for maintenance of automatic equipment.

1.1.12 Project sites, including:

a. discussion of the various sites considered and advantages of the recommended ones,

b. the proximity of residences, industries, and other establishments,

c. any potential sources of pollution that may influence the quality of the supply or interfere with effective operation of the water works system, such as sewage absorption systems, septic tanks, privies, cesspools, sink holes, sanitary landfills, refuse and garbage dumps, etc.

1.1.13 Financing

Provide financial information for new systems as required in Appendix A.

1.1.14 Future extensions

Summarize planning for future needs and services.

1.2 PLANS

Plans for waterworks improvements must, **where pertinent**, provide the following:

1.2.1 General layout, including:

a. suitable title,

b. name of municipality, or other entity or person responsible for the water supply,

c. area or institution to be served,

d. scale, in feet,

e. north point,

f. datum used,

g. boundaries of the municipality or area to be served,

h. date, and name of the designing engineer,

i. ink imprint of registered professional engineer's seal and his signature,

j. legible prints,

k. location and size of existing water mains,

l. location and nature of existing water works structures and appurtenances affecting the proposed improvements.

1.2.2 Detailed plans, including:

a. stream crossings, providing profiles with elevations of the streambed and the normal and extreme high and low water levels,

b. profiles having a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than 10 feet to the inch, with both scales clearly indicated,

c. location and size of the property to be used for the groundwater development with respect to known references such as roads, streams, section lines, or streets,

d. topography and arrangement of present or planned wells or structures, with contour intervals not greater than two feet,

e. elevations of the highest known flood level, floor of the structure, upper terminal of protective casings and outside surrounding grade, using United States Coast and Geodetic Survey, United States Geological Survey or equivalent elevations where applicable as reference,

f. plan and profile drawings of well construction, showing diameter and depth of drill holes, casing and liner diameters and depths, grouting depths, elevations and designation of geological formations, water levels and other details to describe the proposed well completely,

g. location of all existing and potential sources of pollution within 2500 feet of the source and within 100 feet of underground treated water storage facilities,

h. size, length, and identity of sewers, drains, and water mains, and their locations relative to plant structures,

i. schematic flow diagrams and hydraulic profiles showing the flow through various plant units,

j. piping in sufficient detail to show flow through the plant, including waste lines,

k. locations of all chemical storage areas, feeding equipment and points of chemical application (see Part 5),

l. all appurtenances, specific structures, equipment, water treatment plant waste disposal units and points of discharge having any relationship to the plans for water mains and/or water works structures,

m. locations of sanitary or other facilities, such as lavatories, showers, toilets, and lockers.

n. locations, dimensions, and elevations of all proposed plant facilities,

o. locations of all sampling taps,

p. adequate description of any features not otherwise covered by the specifications.

1.3 SPECIFICATIONS

Complete, detailed technical specifications must be supplied for the proposed project, including

a. a program for keeping existing water works facilities in operation during construction of additional facilities so as to minimize interruption of service,

b. laboratory facilities and equipment,

c. the number and design of chemical feeding equipment (see Section 5.1),

d. materials or proprietary equipment for sanitary or other facilities including any necessary backflow or back-siphonage protection.

1.4 DESIGN CRITERIA

A summary of complete design criteria must be submitted for surface water treatment projects, containing but not limited to the following:

a. long-term dependable yield of the source of supply,

b. reservoir surface area, volume, and a volume-versus-depth curve, if applicable,

c. area of watershed, if applicable,

d. estimated average and maximum day water demands for the design period,

e. number of proposed services,

f. fire fighting requirements,

g. flash mix, flocculation and settling basin capacities,

h. retention times,

i. unit loadings,

j. filter area and the proposed filtration rate,

k. backwash rate,

l. feeder capacities and ranges.

1.5 REVISIONS TO APPROVED PLANS

Any changes to approved plans or specifications affecting capacity, hydraulic conditions, operating units, the functioning of water treatment processes, or the quality of water to be delivered, must be re-approved by the reviewing authority before such changes are implemented. Revised plans or specifications should be submitted in time to permit the review and approval of such plans or specifications before any construction work, which will be affected by such changes, is begun.

1.6 ADDITIONAL INFORMATION REQUIRED

The reviewing authority may require additional information that is not part of the construction drawings, such as head loss calculations, proprietary technical data, copies of deeds, copies of contracts, etc.

1.7 DEVIATIONS FROM STANDARDS

The Department, on a case-by-case basis for specific projects, may grant deviations from the mandatory requirements of these standards.

1.7.1 Procedure

a. A person desiring a deviation shall make a request in writing. The request must identify the specific section of the standards to be considered. Adequate justification for the deviation must be provided. "Engineering judgment" or "professional opinion" without supporting data is not considered adequate justification.

b. A panel of three persons from the Department shall review the request, and make a final determination on whether or not a deviation may be granted.

c. A file of all deviations must be maintained by the Department.

CHAPTER 2
GENERAL DESIGN CONSIDERATIONS

2.0 GENERAL

The design of a water supply system or treatment process encompasses a broad area. Application of this part is dependent upon the type of system or process involved.

2.1 DESIGN BASIS

The system including the water source and treatment facilities must be designed for maximum day demand and the design year.

2.2 PLANT LAYOUT

Design should consider

a. functional aspects of the plant layout,

b. provisions for future plant expansion,

c. provisions for expansion of the plant waste treatment and disposal facilities,

d. access roads,

e. site grading,

f. site drainage,

g. walks,

h. driveways,

i. chemical delivery.

2.3 BUILDING LAYOUT

Design should provide for:

a. flexibility of operation,

b. operator safety,

c. convenience of operation,

d. proper chemical storage to prevent contact of incompatible substances and facility damage in the event of chemical spill or container rupture.

2.4 SHOP SPACE AND STORAGE

Adequate facilities should be included for shop space and storage consistent with the designed facilities.

2.5 LABORATORY FACILITIES

Each public water supply must have its own equipment and facilities for routine laboratory testing necessary to ensure proper operation. Laboratory equipment selection must be based on the characteristics of the raw water source, anticipated time spent on-site by the operator, and the complexity of the treatment process involved. Laboratory test kits, which simplify procedures for making one or more tests may be acceptable. An operator or chemist qualified to perform the necessary laboratory tests is essential. Analyses conducted to determine compliance with drinking water regulations, except control testing, must be performed in a Department of Public Health and Human Services certified laboratory in accordance with Standard Methods for the Examination of Water and Wastewater or approved alternative methods. Persons designing and equipping laboratory facilities shall confer with the reviewing authority before beginning the preparation of plans or the purchase of equipment.

2.5.1 Testing equipment

As a minimum, the following laboratory equipment must be provided:

a. Surface water supplies must have a nephelometric turbidimeter meeting the requirements of Standard Methods for the Examination of Water and Wastewater, and must have appropriate equipment and supplies to calibrate the turbidimeter against a primary standard on no less than quarterly intervals.

b. Each surface water treatment plant utilizing coagulation and flocculation including those which lime soften, must have a pH meter, equipment and laboratory supplies for performing jar tests, and titration equipment for both hardness and alkalinity.

c. Each ion-exchange softening plant, and lime-softening plant treating only groundwater must have a pH meter and titration equipment for both hardness and alkalinity.

2.5.2 Physical facilities

Sufficient bench space, adequate ventilation, adequate lighting, storage room, laboratory sink, and auxiliary facilities must be provided. Air conditioning may be necessary.

2.6 MONITORING EQUIPMENT

Water treatment plants must be provided with continuous monitoring equipment (including recorders) to monitor water being discharged to the distribution system as required in Part 4 of these Standards.

2.7 SAMPLE TAPS

Sample taps must be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment. Taps must be consistent with sampling needs and may not be of the petcock type. Taps used for obtaining samples for bacteriological analysis must be of the smooth-nosed type without interior or exterior threads, may not be of the mixing type, and may not have a screen, aerator, or other such appurtenance.

2.8 FACILITY WATER SUPPLY

The facility water supply service line and the plant finished water sample tap must be supplied from a source of finished water at a point where all chemicals have been thoroughly mixed, and the required disinfectant contact time has been achieved (see Section 4.3.2). There may not be any cross-connections between the facility water supply service line and any piping, troughs, tanks, or other treatment units containing wastewater, treatment chemicals, raw or partially treated water.

2.9 WALL CASTINGS

Consideration should be given to providing extra wall castings built into the structure to facilitate future uses whenever pipes pass through walls of concrete structures.

2.10 METERS

All water supplies must have an acceptable means of metering the finished water.

2.11 PIPING COLOR CODE

To facilitate identification of piping in plants and pumping stations it is recommended that the following color scheme be utilized:

Water Lines	
Raw	Olive Green
Settled or Clarified	Aqua
Finished or Potable	Dark Blue
Chemical Lines	
Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow with Green Band
Chlorine (Gas and Solution)	Yellow
Fluoride	Light Blue with Red Band
Lime Slurry	Light Green
Ozone	Yellow with Orange Band
Phosphate Compounds	Light Green with Red Band
Polymers or Coagulant Aids	Orange with Green Band
Potassium Permanganate	Violet
Soda Ash	Light Green with Orange Band
Sulfuric Acid	Yellow with Red Band
Sulfur Dioxide	Light Green with Yellow Band
Waste Lines	
Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (Sanitary or Other)	Dark Gray

Other

Compressed Air	Dark Green
Gas	Red
Other Lines	Light Gray

In situations where two colors do not have sufficient contrast to easily differentiate between them, a six-inch band of contrasting color should be on one of the pipes at approximately 30-inch intervals. The name of the liquid or gas should also be on the pipe. In some cases it may be advantageous to provide arrows indicating the direction of flow.

2.12 MANUALS AND PARTS LISTS

An operation and maintenance manual including a parts list and parts order form must be supplied to the water works as part of any proprietary unit installed in the facility.

2.13 OPERATOR INSTRUCTION

Provisions must be made for operator instruction at the start-up of a plant or pumping station.

2.14 OTHER CONSIDERATIONS

Consideration must be given to the design requirements of other federal, state, and local regulatory agencies for items such as safety requirements, special designs for the handicapped, plumbing and electrical codes, construction in the flood plain, etc.

CHAPTER 3
SOURCE DEVELOPMENT

3.0 GENERAL

In selecting the source of water to be developed, the designing engineer, must prove to the satisfaction of the reviewing authority, that an adequate quantity of water will be available, and that the water which is to be delivered to the consumers will meet the current requirements of the reviewing authority with respect to microbiological, physical, chemical and radiological qualities. Each water supply should take its raw water from the best available source that is economically reasonable and technically possible.

3.1 SURFACE WATER

A surface water source includes all tributary streams and drainage basins, natural lakes and artificial reservoirs or impoundments above the point of water supply intake.

3.1.1 Quantity

The quantity of water at the source must

a. be adequate to meet or exceed the design maximum day demand for the service area as shown by calculations based on the extreme drought of record,

b. provide a reasonable surplus for anticipated growth,

c. be adequate to compensate for all losses such as silting, evaporation, seepage, etc.,

d. be adequate to provide ample water for other legal users of the source.

3.1.2 Quality

A sanitary survey and study must be made of the factors, both natural and man made, which may affect quality. Such survey and study must include, but not be limited to

a. determining possible future uses of impoundments or reservoirs,

b. determining degree of control of watershed by owner,

c. assessing degree of hazard to the supply by accidental spillage of materials that may be toxic, harmful or detrimental to treatment processes,

d. obtaining samples over a sufficient period of time to assess the microbiological, physical, chemical and radiological characteristics of the water,

e. assessing the capability of the proposed treatment process to reduce contaminants to applicable standards,

f. consideration of currents, wind and ice conditions, and the effect of confluencing streams.

3.1.3 Minimum treatment

a. The design of the water treatment plant must consider the worst conditions that may exist during the life of the facility.

b. The Department shall determine the minimum treatment required to ensure compliance with Title 17, Chapter 38, Sub-chapter 2, ARM.

c. Filtration preceded by appropriate pretreatment must be provided for all surface waters. The reviewing authority on a case-by-case basis may approve deviations.

3.1.4 Structures

3.1.4.1 Design of intake structures must provide for:

a. withdrawal of water from more than one level if quality varies with depth,

b. separate facilities for release of less desirable water held in storage,

c. where frazil ice may be a problem, holding the velocity of flow into the intake structure to a minimum, generally not to exceed 0.5 feet per second,

d. inspection manholes every 1000 feet for pipe sizes large enough to permit visual inspection,

e. occasional cleaning of the inlet line,

f. adequate protection against rupture by dragging anchors, ice, etc.,

g. ports located above the bottom of the stream, lake or impoundment, but at sufficient depth to be kept submerged at low water levels,

h. where shore wells are not provided, a diversion device capable of keeping large quantities of fish or debris from entering an intake structure.

3.1.4.2 Shore wells must

a. have motors and electrical controls located above grade, and protected from flooding as required by the reviewing authority,

b. be accessible,

c. be designed against flotation,

d. be equipped with removable or traveling screens before the pump suction well,

e. provide for introduction of chlorine or other chemicals in the raw water transmission main if necessary for quality control,

f. have intake valves and provisions for back flushing or cleaning by a mechanical device and testing for leaks, where practical,

g. have provisions for withstanding surges where necessary.

3.1.4.3 An up ground reservoir

is a facility into which water is pumped during periods of good quality and high stream flow for future release to treatment facilities. Up-ground reservoirs must be constructed to assure that

a. water quality is protected by controlling runoff into the reservoir,

b. dikes are structurally sound and protected against wave action and erosion,

c. intake structures and devices meet requirements of Section 3.1.4.1,

d. point of influent flow is separated from the point of withdrawal,

e. separate pipes are provided for influent to and effluent from the reservoir.

3.1.5 Impoundments and reservoirs

3.1.5.1 Site preparation must provide where applicable:

a. removal of brush and trees to high water elevation,

b. protection from floods during construction,

c. abandonment of all wells that will be inundated, in accordance with requirements of the reviewing authority.

3.1.5.2 Construction may require:

a. approval from the appropriate regulatory agencies of the safety features for stability and spillway design,

b. a permit from an appropriate regulatory agency for controlling stream flow or installing a structure on the bed of a stream or interstate waterway.

3.2 GROUNDWATER

A groundwater source includes all water obtained from dug, drilled, bored or driven wells, and infiltration lines. Prior to construction of a well intended to serve a public water supply, the reviewing authority in accordance with the requirements of this section must approve the proposed location and the plans and specifications. To assess the available water quality and quantity, the reviewing authority may require construction and testing of the source in accordance with the approved plans and specifications and at the approved location prior to approval of other system components. All wells must be constructed by a licensed water well contractor in accordance with Title 37, Chapter 43, MCA and Title 36, Chapter 21, ARM, March,1997, (Water Well Contractor rules) with the following additional requirements.

3.2.1 Quantity

3.2.1.1 Source capacity

The total developed groundwater source capacity must equal or exceed the design maximum day demand and equal or exceed the design average day demand with the largest producing well out of service. Additional capacity will be required if storage is inadequate per Section 7.0.1.b of this circular.

3.2.1.2 Number of sources

A minimum of two sources of groundwater must be provided

3.2.1.3 Auxiliary power

a. When power failure would result in cessation of minimum essential service, sufficient power must be provided to meet average day demand through

   1. connection to at least two independent public power sources, or

   2. portable or in-place auxiliary power.

b. Auxiliary power is not required when

   1. documentation is submitted that shows power outages are infrequent and of short duration, and

   2. fire protection is not diminished by power failure.

c. When automatic pre-lubrication of pump bearings is necessary, and an auxiliary power supply is provided, the pre-lubrication line must be provided with a valved by-pass around the automatic control, or the automatic control must be wired to the emergency power source.

3.2.2 Quality

The Department shall determine, on a case-by-case basis, the minimum treatment required for a groundwater source to ensure compliance with Title 17, Chapter 38, Sub-Chapter 2, ARM.

3.2.2.1 Microbiological quality

a. Disinfection of every new, modified or reconditioned groundwater source

   1. must be provided in accordance with ARM 36.21.662(1) prior to placement of permanent pumping equipment, and

   2. must be provided after placement of permanent pumping equipment.

b. After disinfection, one or more water samples must be submitted to a laboratory certified by the Department of Public Health and Human Services for microbiological analysis with satisfactory results reported to reviewing authority prior to placing the well into service.

c. If MT DEQ determines from the required application materials that the source may be groundwater under the direct influence of surface water in accordance with PWS-5, further assessment or treatment may be required.

3.2.2.2 Physical and chemical quality

a. Every new, modified or reconditioned groundwater source must be examined for applicable physical and chemical characteristics by tests of a representative sample in a laboratory certified by the Department of Public Health and Human Services, with the results reported to the reviewing authority.

b. Samples must be collected at the conclusion of the test pumping procedure and examined as soon as practical. The reviewing authority may require sample results to be submitted to MT DEQ for review and approval to demonstrate compliance with Title 17, Chapter 38, Sub-Chapter 2, ARM, prior to use or construction of a new system.

c. The reviewing authority may require field determinations of physical and chemical constituents or special sampling procedures.

3.2.2.3 Radiological quality

Every new, modified or reconditioned groundwater source must be examined for radiological activity as required by the MT DEQ by tests of a representative sample in a laboratory certified by the Department of Public Health and Human Services, with results reported to reviewing authority.

3.2.3 Location

3.2.3.1 Well location

The reviewing authority must be consulted prior to design and construction regarding a proposed well location as it relates to required separation between existing and potential sources of contamination and groundwater development. Wells must be located at least 100 feet from sewer lines, septic tanks, holding tanks, and any structure used to convey or retain wastewater. Well location(s) must be based on a source water protection assessment conducted in accordance with Section 1.1.8.2 of this circular.

3.2.3.2 Continued protection

Continued protection of the well site from potential sources of contamination must be provided either through ownership, zoning, easements, leasing or other means acceptable to the reviewing authority. Such protection must extend for a radius of at least 100 feet around the well. Also, separation distances between proposed wells and potential sources of contamination must be defined and justified by the design engineer in accordance with Section 1.1.8.2 of this circular. The zone of influence of a proposed or existing well must not be in a groundwater-mixing zone as defined in ARM 17.30.517. The reviewing authority may require fencing of the site.

3.2.4 Testing and records

3.2.4.1 Yield and drawdown tests must:

a. be performed on every production well after construction or subsequent treatment and prior to placement of the permanent pump,

b. have the test methods clearly indicated in the project specifications,

c. have a test pump capacity, at maximum anticipated drawdown, at least 1.5 times the quantity anticipated, and

d. provide for continuous constant rate pumping at 1.5 times the design pump capacity for at least 24 hours. Data collection must begin at time zero. The test may be terminated if stabilized drawdown occurs for at least six hours during the test. If the design pumping rate is 35 gpm or greater, the minimum stabilized drawdown period must be at least eight hours.

e. provide the following data:

   1. static water level,

   2. time of starting and ending each test cycle,

   3. pumping rate,

   4. pumping water levels taken so as to provide at least 10 evenly spaced data points per log cycle of time (in minutes) on a time-drawdown plot,

   5. water recovery levels taken so as to provide at least 10 evenly spaced data points per log cycle of time (in minutes) on a time-drawdown plot.

   Test results must be reported to the reviewing authority. To demonstrate adequate water quantity, the reviewing authority may require that pump test results be submitted to the reviewing authority for review and approval prior to construction of the system.

3.2.4.2 Plumbness and alignment requirements

a. Every well must be tested for plumbness and alignment in accordance with AWWA A100.

b. If the well fails to meet these requirements, it may be accepted by the engineer if it does not interfere with the installation or operation of the pump or uniform placement of grout.

3.2.4.3 Geological data

Must be determined in accordance with ARM 36.21.667 except that samples must be collected at intervals of five feet or less. A copy of the well log must be submitted to the reviewing authority.

3.2.5 General well construction

3.2.5.1 Drilling fluids and additives

Must be approved by the National Sanitation Foundation (NSF) or a similar ANSI accredited laboratory/organization.

3.2.5.2 Minimum protected depths

a. Minimum protected depths of drilled wells must provide watertight construction to such depth as may be required by the reviewing authority, to

   1. exclude contamination, and

   2. seal off formations that are, or may be, contaminated or yield undesirable water.

b. Wells must have unperforated casing to a minimum depth of 25 feet or continuous disinfection must be provided.

c. Water drawn from water table aquifers within 25 feet of ground surface must receive continuous disinfection.

3.2.5.3 Permanent steel casing pipe must:

a. be in accordance with ARM 36.21.640,

b. be equipped with a drive shoe when driven, and

c. have joints in accordance with ARM 36.21.642.

3.2.5.4 Nonferrous casing materials

Plastic well casing must be in accordance with ARM 36.21.645 and ARM 36.21.646.

3.2.5.5 Packers

Packers must be of material that will not impart taste, odor, toxic substance or bacterial contamination to the well water.

3.2.5.6 Screens must:

a. be constructed of materials resistant to damage by chemical action of groundwater or cleaning operations,

b. have size of openings based on sieve analysis of formation and/or gravel pack materials,

c. have sufficient length and diameter to provide adequate specific capacity and low aperture entrance velocity. The entrance velocity may not exceed 0.1 feet per second,

d. be installed so that the pumping water level remains above the screen under all operating conditions,

e. where applicable, be designed and installed to permit removal or replacement without adversely affecting water-tight construction of the well, and

f. be provided with a bottom plate or washdown bottom fitting of the same material as the screen.

3.2.5.7 Grouting requirements

a. All permanent well casing must be sealed in accordance with ARM 36.21.654 through ARM 36.21.660.

b. The casing must be provided with centralizers in accordance with ARM 36.21.649.

3.2.5.8 Upper terminal well construction

a. Permanent casing for all groundwater sources must be in accordance with ARM 36.21.647.

b. Where a well house is constructed, the floor surface must be at least six inches above the final ground elevation.

c. Sites subject to flooding must be provided with an earth mound surrounding the casing and terminating at an elevation at least two feet above the 100 year flood level or highest known flood elevation, or other suitable protection as determined by the reviewing authority.

d. The top of the well casing at sites subject to flooding must terminate at least three feet above the 100 year flood level or the highest known flood elevation, whichever is higher, or as the reviewing authority directs.

3.2.5.9 Development

a. Every well must be developed in accordance with ARM 36.21.653.

b. Where chemical conditioning is required, the specifications must include provisions for the method, equipment, chemicals, testing for residual chemicals, and disposal of waste and inhibitors.

c. Where blasting procedures may be used, the specifications must include the provisions for blasting and cleaning. Special attention must be given to assure that the blasting does not damage the grouting and casing.

3.2.5.10 Capping requirements

Temporary capping must be in accordance with ARM 36.21.661

3.2.5.11 Well abandonment

All wells that have no further use must be abandoned in accordance with ARM 36.21.670 through ARM 36.21.678.

3.2.6 Aquifer types and construction methods -- Special conditions

3.2.6.1 Sand or gravel wells

a. If clay or hardpan is encountered above the water bearing formation, the well must be constructed in accordance with ARM 36.21.657.

b. If a sand or gravel aquifer is overlaid only by permeable soils, the well must be constructed in accordance with ARM 36.21.656.

3.2.6.2 Gravel pack wells

a. Gravel pack must be well rounded particles, 95 per cent siliceous material, that are smooth and uniform, free of foreign material, properly sized, washed and then disinfected immediately prior to or during placement.

b. Gravel pack must be placed in one uniform continuous operation.

c. Gravel refill pipes, when used, must be Schedule 40 steel pipe incorporated within the pump foundation and terminated with screwed or welded caps at least 12 inches above the pump house floor or concrete apron.

d. Gravel refill pipes located in the grouted annular opening must be surrounded by a minimum of 1 1/2 inches of grout.

3.2.6.3 Radial water collector

a. Locations of all caisson construction joints and porthole assemblies must be indicated.

b. The caisson wall must be reinforced to withstand the forces to which it will be subjected.

c. Radial collectors must be in areas and at depths approved by the reviewing authority.

d. Provisions must be made to assure that radial collectors are essentially horizontal.

e. The top of the caisson must be covered with a watertight floor.

f. All openings in the floor must be curbed and protected from entrance of foreign material.

g. The pump discharge piping may not be placed through the caisson walls.

3.2.6.4 Infiltration lines

a. Infiltration lines may be considered only where geological conditions preclude the possibility of developing an acceptable drilled well.

b. The area around infiltration lines must be under the control of the water purveyor for a distance acceptable to or required by the reviewing authority.

c. Flow in the lines must be by gravity to the collecting well.

3.2.6.5 Dug wells

a. Dug wells may be considered only where geological conditions preclude the possibility of developing an acceptable drilled well.

b. A watertight cover must be provided.

c. Minimum protective lining and grouted depth, must be at least ten feet below original or final ground elevation, whichever is lower.

d. Openings must be curbed and protected from entrance of foreign material.

e. Pump discharge piping may not be placed through the well casing or wall.

3.2.6.6 Consolidated formation wells

Drilled wells that penetrate an aquifer either within or overlain by a consolidated formation must be grouted in accordance with ARM 36.21.655.

3.2.6.7 Naturally flowing wells

Must be sealed in accordance with ARM 36.21.658.

3.2.7 Well pumps, discharge piping and appurtenances

3.2.7.1 Line shaft pumps

Wells equipped with line shaft pumps must

a. have the casing firmly connected to the pump structure or have the casing inserted into a recess extending at least one-half inch into the pump base,

b. have the pump foundation and base designed to prevent water from coming into contact with the joint, and

c. avoid the use of oil lubrication at pump settings less than 400 feet.

3.2.7.2 Submersible pumps

Where a submersible pump is used

a. the top of the casing must be effectively sealed against the entrance of water under all conditions of vibration or movement of conductors or cables, and

b. the electrical cable must be firmly attached to the riser pipe at 20-foot intervals or less.

3.2.7.3 Discharge piping

a. The discharge piping must

   1. be designed so that the friction loss will be low,

2. have control valves and appurtenances located above the pump house floor when an aboveground discharge is provided,

3. be protected against the entrance of contamination,

4. be equipped with a check valve, a shutoff valve, a pressure gauge, a means of measuring flow, and a smooth nosed sampling tap located at a point where positive pressure is maintained,

5. where applicable, be equipped with an air release-vacuum relief valve located upstream from the check valve, with exhaust/relief piping terminating in a down-turned position at least 18 inches above the floor and covered with a 24 mesh corrosion resistant screen,

6. be valved to permit test pumping and control of each well,

7. have all exposed piping, valves and appurtenances protected against physical damage and freezing,

8. be properly anchored to prevent movement, and

9. be protected against surge or water hammer.

b. The discharge piping must be provided with a means of pumping to waste, but may not be directly connected to a sewer.

3.2.7.4 Pitless well units

a. Pitless units and pitless adapters submitted as a part of a system need to be specified using manufacturer's name and model number.

b. Pitless units must

1. be shop-fabricated from the point of connection with the well casing to the unit cap or cover,

2. be threaded or welded to the well casing,

3. be of watertight construction throughout,

4. be of materials and weight at least equivalent and compatible to the casing,

5. have field connection to the lateral discharge from the pitless unit of threaded, flanged or mechanical joint connection, and

6. terminate at least 18 inches above final ground elevation or three feet above the 100 year flood level or the highest known flood elevation, whichever is higher, or as the reviewing authority directs.

c. The design of the pitless unit must make provision for

1. access to disinfect the well,

2. a properly constructed casing vent meeting the requirements of Section 3.2.7.5,

3. facilities to measure water levels in the well (see Section 3.2.7.6),

4. a cover at the upper terminal of the well that will prevent the entrance of contamination,

5. a contamination-proof entrance connection for electrical cable,

6. an inside diameter as great as that of the well casing, up to and including casing diameters of 12 inches, to facilitate work and repair on the well, pump, or well screen, and

7. at least one check valve within the well casing.

d. If the connection to the casing is by field weld, the shop-assembled unit must be designed specifically for field welding to the casing. The only field welding permitted will be that needed to connect a pitless unit to the casing.

3.2.7.5 Casing vent

a. Provisions must be made for venting the well casing to atmosphere. Venting must be provided by factory manufactured vented well cap or fabricated vent assembly. All vents must be screened with corrosion resistant material to prevent entry of insects and oriented so as to prevent entry of rainwater.

b. Fabricated vents must terminate in a down turned position, at or above the top of the casing or pitless unit in a minimum 1 1/2 inch diameter opening covered with a 24-mesh screen. The pipe connecting the casing to the vent must be of adequate size to provide rapid venting of the casing. Fabricated vent assemblies must be of such design and strength as to be vandal resistant.

3.2.7.6 Water level measurement

a. Provisions (i.e. probe access tube or air line) must be made for periodic measurement of water levels in the completed well.

b. Where pneumatic water level measuring equipment is used it must be made using corrosion resistant materials attached firmly to the drop pipe or pump column and in such a manner as to prevent entrance of foreign materials.

3.2.7.7 Observation wells must be:

a. constructed in accordance with the requirements for permanent wells if they are to remain in service after completion of a water supply well, and

b. protected at the upper terminal to preclude entrance of foreign materials.

3.2.7.8 Well houses

Must be designed to meet the pertinent sections of Part 6.

CHAPTER 4
TREATMENT

4.0 GENERAL

The design of treatment processes and devices must depend on evaluation of the nature and quality of the particular water to be treated, the desired quality of the finished water and the mode of operation planned.

4.1 CLARIFICATION

Plants designed for processing surface water must

a. provide a minimum of two units each for rapid mix, flocculation and sedimentation,

b. be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time,

c. provide multiple-stage treatment facilities when required by the reviewing authority,

d. be started manually following shutdown,

e. minimize hydraulic head losses between units to allow future changes in processes without the need for re-pumping.

4.1.1 Presedimentation

Waters containing high turbidity may require pretreatment, usually sedimentation either with or without the addition of coagulation chemicals.

a. Basin design -- Presedimentation basins should have hopper bottoms or be equipped with continuous mechanical sludge removal apparatus, and provide arrangements for dewatering.

b. Inlet -- Incoming water must be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented.

c. Bypass - Provisions for bypassing presedimentation basins must be included.

d. Detention time -- Three hours detention is the minimum period recommended; greater detention may be required.

4.1.2 Mixing

Mixing must rapidly disperse chemicals throughout the water to be treated, usually by violent agitation. The engineer must submit the design basis for the velocity gradient (G value) selected, considering the chemicals to be added and water temperature, color and other related water quality parameters. The engineer must also submit the design basis for the type of mixer selected. Whenever pilot studies are required, mixer designs must be based upon the results of the study. The mixer and the flocculation basin must be as close together as possible.

4.1.3 Flocculation

Flocculation means the agitation of water at low velocities for long periods of time.

a. Basin Design -- Inlet and outlet design must prevent short-circuiting and destruction of floc. A drain and/or pumps must be provided to handle dewatering and sludge removal. Three-stage flocculation must be provided for conventional complete treatment plants.

b. Detention -- The flow-through velocity may not be less than 0.5 nor greater than 1.5 feet per minute, with a detention time for floc formation of at least 30 minutes.

c. Equipment -- Agitators must be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 3.0 feet per second.

d. Piping -- Flocculation and sedimentation basins must be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins may not be less than 0.5 nor greater than 1.5 feet per second. Allowances must be made to minimize turbulence at bends and changes in direction.

e. Other designs -- Baffling may be used to provide for flocculation in small plants only after consultation with the reviewing authority. The design should be such that the velocities and flows noted above will be maintained.

f. Superstructure -- A superstructure over the flocculation basins may be required.

4.1.4 Sedimentation

Sedimentation must follow flocculation, except in direct filtration facilities. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional sedimentation units:

a. Detention time -- Detention time must provide a minimum of four hours of settling time. This may be reduced to two hours for lime-soda softening facilities treating only groundwater. Reduced sedimentation time may also be approved when equivalent effective settling is demonstrated.

b. Inlet devices -- Inlets must be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin.

c. Outlet devices -- Outlet devices must be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow.

d. Overflow rate -- The rate of flow over the outlet weir may not exceed 20,000 gallons per day per foot of weir length. Where submerged orifices are used as an alternate for overflow weirs, they should be not lower than three feet below the flow line with flow rates equivalent to weir loadings.

e. Velocity -- The velocity through settling basins may not exceed 0.5 feet per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification.

f. Overflow -- An overflow weir (or pipe) should be installed which will establish the maximum water level desired on top of the filters. It must discharge by gravity with a free fall at a location where the discharge will be noted.

g. Superstructure -- A superstructure over the sedimentation basins may be required. If there is no mechanical equipment in the basins and if provisions are included for adequate monitoring under all expected weather conditions, a cover may be provided in lieu of a superstructure.

h. Sludge collection -- Mechanical sludge collection equipment must be provided.

i. Drainage -- Basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than one foot in twelve feet where mechanical sludge collection equipment is not required.

j. Flushing lines -- Flushing lines or hydrants must be provided and must be equipped with backflow prevention devices acceptable to the reviewing authority.

k. Safety -- Permanent ladders or handholds should be provided on the inside walls of basins above the water level. Guardrails should be included.

l. Sludge removal -- Sludge removal design must provide that

   1. sludge pipes must be not less than three inches in diameter and so arranged as to facilitate cleaning,

   2. entrance to sludge withdrawal piping must prevent clogging,

   3. valves must be located outside the tank for accessibility,

   4. the operator may observe and sample sludge being withdrawn from the unit.

m. Sludge disposal -- Facilities are required by the reviewing authority for disposal of sludge. (See Section 4.11.) Provisions must be made for the operator to observe and sample sludge being withdrawn from the unit.

4.1.5 Solids contact unit

Units are generally acceptable for combined softening and clarification where water characteristics, especially temperature, do not fluctuate rapidly, flow rates are uniform and operation is continuous. Before such units are considered as clarifiers without softening, specific approval of the reviewing authority must be obtained. Clarifiers should be designed for the maximum uniform rate and should be adjustable to changes in flow that are less than the design rate and for changes in water characteristics. A minimum of two units are required for surface water treatment.

4.1.5.1 Installation of equipment

Supervision by a representative of the manufacturer must be provided with regard to all mechanical equipment at the time of

a. installation, and

b. initial operation.

4.1.5.2 Operating equipment

The following must be provided for plant operation:

a. a complete outfit of tools and accessories,

b. necessary laboratory equipment,

c. adequate piping with suitable sampling taps so located as to permit the collection of samples of water from critical portions of the units.

4.1.5.3 Chemical feed

Chemicals must be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water.

4.1.5.4 Mixing

A rapid mix device or chamber ahead of solids contact units may be required by the reviewing authority to assure proper mixing of the chemicals applied. Mixing devices employed must be so constructed as to

a. provide good mixing of the raw water with previously formed sludge particles, and

b. prevent deposition of solids in the mixing zone.

4.1.5.5 Flocculation

Flocculation equipment

a. must be adjustable (speed and/or pitch),

b. must provide for coagulation in a separate chamber or baffled zone within the unit,

c. should provide the flocculation and mixing period to be not less than 30 minutes.

4.1.5.6 Sludge concentrators

a. The equipment should provide either internal or external concentrators in order to obtain a concentrated sludge with a minimum of wastewater.

b. Large basins should have at least two sumps for collecting sludge with one sump located in the central flocculation zone.

4.1.5.7 Sludge removal

Sludge removal design must provide that

a. sludge pipes must be not less than three inches in diameter and so arranged as to facilitate cleaning,

b. entrance to sludge withdrawal piping must prevent clogging,

c. valves must be located outside the tank for accessibility, and

d. the operator may observe and sample sludge being withdrawn from the unit.

4.1.5.8 Cross-connections

a. Blow-off outlets and drains must terminate and discharge at places satisfactory to the reviewing authority.

b. Cross-connection control must be included for the potable water lines used to back flush sludge lines.

4.1.5.9 Detention period

The detention time must be established on the basis of the raw water characteristics and other local conditions that affect the operation of the unit. Based on design flow rates, the detention time should be

a. two to four hours for suspended solids contact clarifiers and softeners treating surface water, and

b. one to two hours for the suspended solids contact softeners treating only groundwater.

The reviewing authority may alter detention time requirements.

4.1.5.10 Suspended slurry concentrate

Softening units should be designed so that continuous slurry concentrates of one per cent or more, by weight, can be satisfactorily maintained.

4.1.5.11 Water losses

a. Units must be provided with suitable controls for sludge withdrawal.

b. Total water losses should not exceed

    1. five per cent for clarifiers,

    2. three per cent for softening units.

c. Solids concentration of sludge bled to waste should be

    1. three per cent by weight for clarifiers,

    2. five per cent by weight for softeners.

4.1.5.12 Weirs or orifices

The units should be equipped with either overflow weirs or orifices constructed so that water at the surface of the unit does not travel over 10 feet horizontally to the collection trough.

a. Weirs must be adjustable, and at least equivalent in length to the perimeter of the tank.

b. Weir loading may not exceed

   1. 10 gallons per minute per foot of weir length for units used for clarifiers,

   2. 20 gallons per minute per foot of weir length for units used for softeners.

c. Where orifices are used the loading per foot of launder rates should be equivalent to weir loadings. Either must produce uniform rising rates over the entire area of the tank.

4.1.5.13 Upflow rates

Unless supporting data is submitted to the reviewing authority to justify rates exceeding the following, rates may not exceed

a. 1.0 gallon per minute per square foot of area at the sludge separation line for units used for clarifiers,

b. 1.75 gallons per minute per square foot of area at the slurry separation line, for units used for softeners.

4.1.6 Tube or plate settlers

Proposals for settler unit clarification may be required to include pilot plant and/or full-scale demonstration satisfactory to the reviewing authority prior to the preparation of final plans and specifications for approval. Settler units consisting of variously shaped tubes or plates which are installed in multiple layers and at an angle to the flow may be used for sedimentation, following flocculation.

4.1.6.1 General Criteria

a. Inlet and outlet considerations -- Design to maintain velocities suitable for settling in the basin and to minimize short-circuiting.

b. Drainage -- Drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant.

c. Protection from freezing -- Although most units will be located within a plant, outdoor installations must provide sufficient freeboard above the top of settlers to prevent freezing in the units. A cover or enclosure is strongly recommended.

d. Application rate -- A maximum rate of 2 gal/ft^2/min of cross-sectional area (based on 24-inch long 60E tubes or 39.5-inch long 7 1/2E tubes), unless higher rates are successfully shown through pilot or plant or in-plant demonstration studies.

e. Flushing lines -- Flushing lines must be provided to facilitate maintenance and must be properly protected against backflow or back siphonage.

4.2 FILTRATION

Acceptable filters must include, upon the discretion of the reviewing authority, the following types:

a. rapid rate gravity filters,

b. rapid rate pressure filters,

c. diatomaceous earth filtration,

d. slow sand filtration,

The application of any one type must be supported by water quality data representing a reasonable period of time to characterize the variations in water quality. Experimental treatment studies may be required to demonstrate the applicability of the method of filtration proposed. Filter media must meet the requirements of ANSI/NSF Standard 61 or otherwise be acceptable to the reviewing authority.

4.2.1 Rapid rate gravity filters

4.2.1.1 Pretreatment

The use of rapid rate gravity filters must require pretreatment.

4.2.1.2 Rate of filtration

The rate of filtration must be determined through consideration of such factors as raw water quality, degree of pretreatment provided, filter media, water quality control parameters, competency of operating personnel, and other factors as required by the reviewing authority. In any case, the filter rate must be proposed and justified by the designing engineer to the satisfaction of the reviewing authority prior to the preparation of final plans and specifications.

4.2.1.3 Number

At least two units must be provided. Where only two units are provided, each must be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters must be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service. Where declining rate filtration is provided, the variable aspect of filtration rates, and the number of filters must be considered when determining the design capacity for the filters.

4.2.1.4 Structural details and hydraulics

The filter structure must be designed to provide for

a. vertical walls within the filter,

b. no protrusion of the filter walls into the filter media,

c. cover by superstructure as determined necessary under local climate,

d. head room to permit normal inspection and operation,

e. minimum depth of filter box of 8 feet,

f. minimum water depth over the surface of the filter media of three feet,

g. trapped effluent to prevent backflow of air to the bottom of the filters,

h. prevention of floor drainage to the filter with a minimum 4-inch curb around the filters,

i. prevention of flooding by providing overflow,

j. maximum velocity of treated water in pipe and conduits to filters of two feet per second,

k. cleanouts and straight alignment for influent pipes or conduits where solids loading is heavy, or following lime-soda softening,

l. wash water drain capacity to carry maximum flow,

m. walkways around filters, to be not less than 24 inches wide,

n. safety handrails or walls around filter areas adjacent to normal walkways,

o. construction to prevent cross connections and common walls between potable and non-potable water.

4.2.1.5 Wash water troughs

Wash water troughs should be constructed to have,

a. the bottom elevation above the maximum level of expanded media during washing,

b. a two-inch freeboard at the maximum rate of wash,

c. the top edge level and all at the same elevation,

d. spacing so that each trough serves the same number of square feet of filter area,

e. maximum horizontal travel of suspended particles to reach the trough not to exceed three feet.

4.2.1.6 Filter material

The media must be clean silica sand or other natural or synthetic media approved by the reviewing authority, having the following characteristics:

a. a total depth of not less than 24 inches and generally not more than 30 inches,

b. an effective size range of the smallest material no greater than 0.45 mm to 0.55 mm,

c. a uniformity coefficient of the smallest material not greater than 1.65,

d. a minimum of 12 inches of media with an effective size range no greater than 0.45 mm to 0.55 mm, and a specific gravity greater than other filtering materials within the filter.

e. Types of filter media:

   1. Anthracite - Clean crushed anthracite, or a combination of anthracite and other media may be considered on the basis of experimental data specific to the project, and must have

      a. effective size of 0.45 mm - 0.55 mm with uniformity coefficient not greater than 1.65 when used alone,

      b. effective size of 0.8 mm - 1.2 mm with a uniformity coefficient not greater than 1.85 when used as a cap,

      c. effective size for anthracite used on potable groundwater for iron and manganese removal only must be a maximum of 0.8 mm (effective sizes greater than 0.8 mm may be approved based upon onsite pilot plant studies).

   2. Sand - sand must have

      a. effective size of 0.45 mm to 0.55 mm,

      b. uniformity coefficient of not greater than 1.65.

   3. Granular activated carbon (GAC) - Granular activated carbon media may be considered only after pilot or full scale testing and with prior approval of the reviewing authority. The design must include the following:

      a. The media must meet the basic specifications for filter media as given in Section 4.2.1.6. a through d except that larger size media may be allowed by the reviewing authority where full scale tests have demonstrated that treatment goals can be met under all conditions.

      b. There must be provisions for a free chlorine residual and adequate contact time in the water following the filters and prior to distribution (See 4.3.2.d and 4.3.3).

      c. There must be means for periodic treatment of filter material for control of bacterial and other growth.

      d. Provisions must be made for frequent replacement or regeneration if GAC is used for filtration.

   4. Other media -- Other media will be considered based on experimental data and operating experience.

   5. Torpedo sand -- A three-inch layer of torpedo sand should be used as a supporting media for filter sand, and should have

      a. effective size of 0.8 mm to 2.0 mm, and

      b. uniformity coefficient not greater than 1.7.

6. Gravel -- Gravel, when used as the supporting media must consist of hard, durable, rounded silica particles and may not include flat or elongated particles. The coarsest gravel must be 2 1/2 inches in size when the gravel rests directly on the strainer system, and must extend above the top of the perforated laterals. Not less than four layers of gravel must be provided in accordance with the following size and depth distribution when used with perforated laterals:

Size	Depth
2 1/2 to 1 1/2 inches	5 to 8 inches
1 1/2 to 3/4 inches	3 to 5 inches
3/4 to 1/2 inches	3 to 5 inches
1/2 to 3/16 inches	2 to 3 inches
3/16 to 3/32 inches	2 to 3 inches

Reduction of gravel depths may be considered upon justification to the reviewing authority when proprietary filter bottoms are specified.

4.2.1.7 Filter bottoms and strainer systems

Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms may not be used where iron or manganese may clog them or with waters softened by lime. The design of manifold-type collection systems must:

a. minimize loss of head in the manifold and laterals,

b. assure even distribution of wash water and even rate of filtration over the entire area of the filter,

c. provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003,

d. provide the total cross-sectional area of the laterals at about twice the total area of the final openings,

e. provide the cross-sectional area of the manifold at 1 1/2 to 2 times the total area of the laterals.

4.2.1.8 Surface wash or subsurface wash

Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or revolving-type apparatus. All devices must be designed with

a. provision for water pressures of at least 45 psi,

b. a properly installed vacuum breaker or other approved device to prevent back siphonage if connected to the treated water system,

c. rate of flow of 2.0 gallons per minute per square foot of filter area with fixed nozzles or

0.5 gallons per minute per square foot with revolving arms,

d. air wash can be considered based on experimental data and operating experiences.

4.2.1.9 Air scouring

Air scouring can be considered in place of surface wash

a. air flow for air scouring the filter must be 3-5 standard cubic feet per minute per square foot,

b. concurrent wash water rates must not exceed 8 gallons per minute per square foot unless a method of retaining the filter media is provided,

c. air scouring must be followed by a fluidization wash sufficient to restratify the media,

d. air must be free from contamination,

e. air wash piping may not be placed in the filter media,

f. under drain and air manifold must be designed to accommodate air and water backwash, and

g. provisions of Section 4.2.1.11 must be followed.

4.2.1.10 Appurtenances

a. The following must be provided for every filter:

    1. influent and effluent sampling taps,

    2. an indicating loss of head gauge,

    3. an indicating rate-of-flow meter. A modified rate controller, which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow onto the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with the reviewing authority,

    4. A continuous monitoring and recording turbidimeter for surface water treatment plants.

b. It is recommended the following be provided for every filter:

    1. wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing,

    2. a 1 to 1 1/2 inch pressure hose and storage rack at the operating floor for washing filter walls,

    3. provisions for filtering to waste with appropriate measures for backflow prevention (see Section 4.11).

4.2.1.11 Backwash

Provisions must be made for washing filters as follows:

a. a minimum rate of 15 gallons per minute per square foot, consistent with water temperatures and specific gravity of the filter media. A rate of 20 gallons per minute per square foot or a rate necessary to provide for a 50 percent expansion of the filter bed is recommended. A reduced rate of 10 gallons per minute per square foot may be acceptable for full depth anthracite or granular activated carbon filters,

b. filtered water provided at the required rate by wash water tanks, a wash water pump, from the high service main, or a combination of these,

c. wash water pumps in duplicate unless an alternate means of obtaining wash water is available,

d. not less than 15 minutes wash of one filter at the design rate of wash,

e. a wash water regulator or valve on the main wash water line to obtain the desired rate of filter wash with the wash water valves on the individual filters open wide,

f. a rate-of-flow indicator, preferably with a totalizer, on the main wash water line, located so that the operator can easily read it during the washing process,

g. design to prevent rapid changes in backwash water flow.

4.2.1.12 Miscellaneous

Roof drains may not discharge into the filters or basins and conduits preceding the filters.

4.2.2 Rapid rate pressure filters

The normal use of these filters is for iron and manganese removal. Pressure filters may be used in the filtration of surface or other polluted waters or following lime-soda softening with the approval of the reviewing authority. Pilot studies must be conducted to justify the use of pressure filters to treat surface water or other polluted waters.

4.2.2.1 General

Minimum criteria relative to number, rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate.

4.2.2.2 Rate of filtration

The rate may not exceed three gallons per minute per square foot of filter area except where in-plant testing or pilot testing as approved by the reviewing authority has demonstrated satisfactory results at higher rates.

4.2.2.3 Details of design

The filters must be designed to provide for

a. loss of head gauges and sample access on the inlet and outlet pipes of each filter,

b. an easily readable meter or flow indicator on each battery of filters. A flow indicator is recommended for each filtering unit,

c. filtration and backwashing of each filter individually with an arrangement of piping as simple as possible to accomplish these purposes,

d. minimum sidewall shell height of five feet. A corresponding reduction in sidewall height is acceptable where proprietary bottoms permit reduction of the gravel depth,

e. the top of the wash water collectors to be at least 18 inches above the surface of the media,

f. the under drain system to efficiently collect the filtered water and to uniformly distribute the backwash water at a rate not less than 15 gallons per minute per square foot of filter area,

g. backwash flow indicators and controls that are easily readable while operating the control valves,

h. an air release valve on the highest point of each filter,

i. an accessible manhole to facilitate inspection and repairs,

j. means to observe the wastewater during backwashing,

k. construction to prevent cross-connection.

4.2.3 Diatomaceous earth filtration

The use of these filters may be considered for application to surface waters with low turbidity and low bacterial contamination, and may be used for iron removal for ground waters providing the removal is effective and the water is of satisfactory sanitary quality before treatment.

4.2.3.1 Conditions of use

Diatomaceous earth filters are expressly excluded from consideration for the following conditions:

a. bacteria removal,

b. color removal,

c. turbidity removal where either the gross quantity of turbidity is high or the turbidity exhibits poor filterability characteristics,

d. filtration of waters with high algae counts.

4.2.3.2 Pilot plant study

Installation of a diatomaceous earth filtration system must be preceded by a pilot plant study on the water to be treated.

a. Conditions of the study such as duration, filter rates, head loss accumulation, slurry feed rates, turbidity removal, bacteria removal, etc., must be approved by the reviewing authority prior to the study.

b. Satisfactory pilot plant results must be obtained prior to preparation of final construction plans and specifications.

c. The pilot plant study must demonstrate the ability of the system to meet applicable drinking water standards at all times.

4.2.3.3 Types of filters

Pressure or vacuum diatomaceous earth filtration units will be considered for approval. However, the vacuum type is preferred for its ability to accommodate a design which permits observation of the filter surfaces to determine proper cleaning, damage to a filter element, and adequate coating over the entire filter area.

4.2.3.4 Treated water storage

Treated water storage capacity in excess of normal requirements must be provided to:

a. allow operation of the filters at a uniform rate during all conditions of system demand at or below the approved filtration rate, and

b. guarantee continuity of service during adverse raw water conditions without bypassing the system.

4.2.3.5 Number of units

See Section 4.2.1.3

4.2.3.6 Precoat

a. Application - A uniform precoat must be applied hydraulically to each septum by introducing a slurry to the tank influent line and employing a filter-to-waste or recirculation system.

b. Quantity - Diatomaceous earth in the amount of 0.1 pounds per square foot of filter area or an amount sufficient to apply a 1/16-inch coating should be used with recirculation. When precoating is accomplished with a filter-to-waste system, 0.15 - 0.2 pounds per square foot of filter area is recommended.

4.2.3.7 Body feed

A body feed system to apply additional amounts of diatomaceous earth slurry during the filter run is required to avoid short filter runs or excessive head losses.

a. Quantity - Rate of body feed is dependent on raw water quality and characteristics and must be determined in the pilot plant study.

b. Operation and maintenance can be simplified by providing accessibility to the feed system and slurry lines.

c. Continuous mixing of the body feed slurry is required.

4.2.3.8 Filtration

a. Rate of filtration - The recommended nominal rate is 1.0 gallon per minute per square foot of filter area with a recommended maximum of 1.5 gallons per minute per square foot. The filtration rate must be controlled by a positive means.

b. Head loss - The head loss may not exceed 30 psi for pressure diatomaceous earth filters, or a vacuum of 15 inches of mercury for a vacuum system.

c. Recirculation - A recirculation or holding pump must be employed to maintain differential pressure across the filter when the unit is not in operation in order to prevent the filter cake from dropping off the filter elements. A minimum recirculation rate of 0.1 gallon per minute per square foot of filter area must be provided.

d. Septum or filter element - The filter elements must be structurally capable of withstanding maximum pressure and velocity variations during filtration and backwash cycles, and must be spaced such that no less than one inch is provided between elements or between any element and a wall.

e. Inlet design - The filter influent must be designed to prevent scour of the diatomaceous earth from the filter element.

4.2.3.9 Backwash

A satisfactory method to thoroughly remove and dispose of spent filter cake must be provided.

4.2.3.10 Appurtenances

The following must be provided for every filter:

a. sampling taps for raw and filtered water,

b. loss of head or differential pressure gauge,

c. rate-of-flow indicator, preferably with totalizer,

d. a throttling valve used to reduce rates below normal during adverse raw water conditions,

e. evaluation of the need for body feed, recirculation, and any other pumps, in accordance with Section 6.3.

4.2.3.11 Monitoring

A continuous monitoring turbidimeter with recorder is required on the filter effluent for plants treating surface water.

4.2.4 Slow rate gravity filters

The use of these filters will require prior engineering studies to demonstrate the adequacy and suitability of this method of filtration for the specific raw water supply.

4.2.4.1 Quality of raw water

Slow rate gravity filtration must *be* limited to waters having maximum turbidities of 50 units and maximum color of 30 units; such turbidity must not be attributable to colloidal clay. Raw water quality data must include examinations for algae.

4.2.4.2 Number

At least two units must be provided. Where only two units are provided, each must be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters must be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

4.2.4.3 Structural details and hydraulics

Slow rate gravity filters must be so designed as to provide:

a. a cover,

b. headroom to permit normal movement by operating personnel for scraping and sand removal operations,

c. adequate manholes and access ports for handling of sand,

d. filtration to waste,

e. an overflow at the maximum filter water level.

4.2.4.4 Rates of filtration

The permissible rates of filtration must be determined by the quality of the raw water and experimental data derived from the water to be treated. The nominal rate may be 45 to 150 gallons per day per square foot of sand area, with somewhat higher rates acceptable when demonstrated to the satisfaction of the approving authority.

4.2.4.5 Under drains

Each filter unit must be equipped with a main drain and an adequate number of lateral under drains to collect the filtered water. The under drains must be so spaced that the maximum velocity of the water flow in the under drain will not exceed 0.75 feet per second. The maximum spacing of laterals may not exceed 3 feet if pipe laterals are used.

4.2.4.6 Filtering material

a. Filter sand must be placed on graded gravel layers for a minimum depth of 30 inches.

b. The effective size must be between 0.30 mm and 0.45 mm.

c. The uniformity coefficient may not exceed 2.5.

d. The sand must be clean and free from foreign matter.

4.2.4.7 Filter gravel

The supporting gravel must conform to the size and depth distribution provided for rapid rate gravity filters. See 4.2.1.6.e.5,6.

4.2.4.8 Depth of water on filter beds

Design must provide a depth of at least three feet of water over the sand. Influent water may not scour the sand surface.

4.2.4.9 Control appurtenances

Each filter must be equipped with:

a. loss of head gauge,

b. an orifice, Venturi meter, or other suitable metering device installed on each filter to control the rate of filtration,

c. an effluent pipe designed to maintain the water level above the top of the filter sand.

d. an effluent sample tap

4.2.5 Direct filtration

Direct filtration, as used herein, refers to the filtration of a surface water without prior settling. The nature of the treatment process will depend upon the raw water quality. A full-scale direct filtration plant may not be constructed without prior pilot studies, which are acceptable to the reviewing authority. In-plant demonstration studies may be appropriate where conventional treatment plants are converted to direct filtration. Where direct filtration is proposed, an engineering report must be submitted prior to conducting pilot plant or in-plant demonstration studies.

4.2.5.1 Engineering report

In addition to the items considered in Section 1.1, "Engineering Report," the report should include a historical summary of meteorological conditions and of raw water quality with special reference to fluctuations in quality, and possible sources of contamination. The following raw water parameters should be evaluated in the report:

a. color,

b. turbidity,

c. bacterial concentration,

d. microscopic biological organisms, including algae,

e. temperature,

f. total solids,

g. general inorganic chemical characteristics,

h. additional parameters as required by the reviewing authority,

i. trihalomethane precursors.

The report should also include a description of methods and work to be done during a pilot plant study or, where appropriate, an in-plant demonstration study.

4.2.5.2 Pilot plant studies

After approval of the engineering report, a pilot study or in-plant demonstration study must be conducted. The study must be conducted over a sufficient time to treat all expected raw water conditions throughout the year. The study must emphasize but not be limited to, the following items:

a. chemical mixing conditions including shear gradients and detention periods,

b. chemical feed rates,

c. use of various coagulants and coagulant aids,

d. flocculation conditions,

e. filtration rates,

f. filter gradation, types of media and depth of media,

g. filter breakthrough conditions, and

h. adverse impact of recycling backwash water due to solids, algae, trihalomethane formation and similar problems.

Prior to the initiation of design plans and specifications, a final report including the engineer's design recommendations must be submitted to the reviewing authority.

The pilot plant filter must be of a similar type and operated in the same manner as proposed for full-scale operation.

4.2.5.3 Pretreatment -- Rapid mix and flocculation

The final rapid mix and flocculation basin design should be based on the pilot plant or in-plant demonstration studies augmented with applicable portions of Section 4.1.2, "Rapid Mix" and Section 4.1.3, "Flocculation."

4.2.5.4 Filtration

a. Filters should be rapid rate gravity or pressure filters with dual or mixed media. The final filter design should be based on the pilot plant or in-plant demonstration studies augmented by applicable portions of Section 4.2.1, "Rapid Rate Gravity Filters." Single media sand filters may not be used.

b. Surface wash, subsurface wash or air scour must be provided for the filters in accordance with 4.2.1.8 and 4.2.1.9.

c. Provisions for filtration to waste with appropriate measures for backflow prevention may be required by the reviewing authority.

4.2.5.5 Control and operation

a. A continuous monitoring and recording turbidimeter must be installed on each filter effluent line. Effluent sample taps must be available whether or not turbidimeters are installed.

b. Additional continuous monitoring equipment to assist in control of coagulant dose may be required by the reviewing authority.

4.2.5.6 Siting requirements

The plant design and land ownership surrounding the plant must allow for the installation of conventional sedimentation basins should it be found that such are necessary.

4.3 DISINFECTION

Chlorine is the preferred disinfecting agent. Chlorination may be accomplished with liquid chlorine, calcium or sodium hypochlorites or chlorine dioxide. Other disinfecting agents will be considered, providing reliable application equipment is available and testing procedures for a residual are recognized in "Standard Methods for the Examination of water and Wastewater," latest edition. Disinfection is required at all surface water supplies and at any groundwater supply of questionable sanitary quality, or where any other treatment, i.e., chemical addition, is provided. Continuous disinfection is recommended for all water supplies. The potential for formation of unacceptable levels of disinfection by-products must be addressed.

4.3.1 Chlorination equipment

4.3.1.1 Type

Solution-feed gas chlorinators or hypochlorite feeders of the positive displacement type must be provided. (See Chapter 5.)

4.3.1.2 Capacity

The chlorinator capacity must be such that a free chlorine residual of at least 2 milligrams per liter can be maintained in the water after contact time of at least 30 minutes when maximum flow rate coincides with anticipated maximum chlorine demand. Higher free chlorine residuals and longer chlorine contact times may be required. The equipment must be of such design that it will operate accurately over the desired feeding range.

4.3.1.3 Standby equipment

Where chlorination is required for protection of the supply, standby equipment of sufficient capacity must be available to replace the largest unit. Spare parts must be made available to replace parts subject to wear and breakage. If there is a large difference in feed rates between routine and emergency dosages, a gas metering tube should be provided for each dose range to ensure accurate control of the chlorine feed.

4.3.1.4 Automatic switchover

Where necessary to protect the public health, automatic switchover of chlorine cylinders must be provided to assure continuous disinfection.

4.3.1.5 Automatic proportioning

Automatic proportioning chlorinators will be required where the rate of flow or chlorine demand is not reasonably constant.

4.3.1.6 Eductor

Each eductor must be selected for the point of application with particular attention given to the quantity of chlorine to be added, the maximum injector water flow, the total discharge back pressure, the injector operating pressure, and the size of the chlorine solution line. Gauges for measuring water pressure and vacuum at the inlet and outlet of each eductor should be provided.

4.3.1.7 Injector/diffuser

The chlorine solution injector/diffuser must be compatible with the point of application to provide a rapid and thorough mix with all the water being treated. The center of a pipeline is the preferred application point.

4.3.2 Contact time and point of application

a. Due consideration must be given to the contact time of the chlorine in water with relation to pH, ammonia, taste-producing substances, temperature, bacterial quality, trihalomethane formation potential and other pertinent factors. Chlorine should be applied at a point that will provide adequate contact time. All basins used for disinfection must be designed to minimize short-circuiting.

b. At plants treating surface water, provisions should be made for applying chlorine to the raw water, settled water, filtered water, and water entering the distribution system. The contact time as required in 4.3.2.d must be provided after filtration unless otherwise approved by the reviewing authority.

c. As a minimum, at plants treating groundwater, provisions should be made for applying chlorine to the detention basin inlet and water entering the distribution system.

d. Free residual chlorination is the preferred practice. **A contact time as required by MDEQ must be provided.** Contact time must be based on tables in Appendix E of the EPA document, "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources", March 1991 Edition. Contact times for removal of both Giardia cysts and viruses must be considered, where applicable. The contact time will depend upon water pH and temperature, the design of the contact basin, method of filtration, the proposed disinfectant, minimum disinfectant residual at the exit of the contact basin and treatment process control.

e. Smooth-nose sample taps must be provided before and after the point of disinfectant application in accordance with Part 2.

4.3.3 Residual chlorine

Minimum free chlorine residual at distant points in a water distribution system should be 0.2 to 0.5 milligrams per liter. Combined chlorine residuals, if appropriate, should be 1.0 to 2.0 milligrams per liter at distant points in the distribution system.

Higher residuals may be required depending on pH, temperature and other characteristics of the water.

4.3.4 Testing equipment

Chlorine residual test equipment, recognized in the latest edition of Standard Methods for Examination of Water and Wastewater, must be provided and should be capable of measuring residuals to the nearest 0.1 milligrams per liter in the range below 0.5 milligrams per liter, to the nearest 0.3 milligrams per liter between 0.5 milligrams per liter and 1.0 milligrams per liter and to the nearest 0.5 milligrams per liter between 1.0 milligrams per liter and 2.0 milligrams per liter. Automatic chlorine residual recorders should be provided where the chlorine demand varies appreciably over a short period of time. All surface water treatment plants must be equipped with recording chlorine analyzers monitoring water entering the distribution system, except as allowed by the MDEQ. (See Section 2.8.)

4.3.5 Chlorinator piping

4.3.5.1 Cross-connection protection

The chlorinator water supply piping must be designed to prevent contamination of the treated water supply by sources of questionable quality. At all facilities treating surface water, pre- and post-chlorination systems must be independent to prevent possible siphoning of partially treated water into the clear well. The water supply to each eductor must have a separate shut-off valve. No master shut-off valve will be allowed.

4.3.5.2 Pipe material

The pipes carrying elemental liquid or dry gaseous chlorine under pressure must be Schedule 80 seamless steel tubing or other materials recommended by the Chlorine Institute (never use PVC). Rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute must be used for chlorine solution piping and fittings. Nylon products are not acceptable for any part of the chlorine solution piping system.

4.3.6 Housing

Adequate housing must be provided for the chlorination equipment and for storing the chlorine. (See Chapter 5.)

4.3.7 Other disinfecting agents

Although disinfecting agents other than chlorine are available, each has usually demonstrated shortcomings when applied to a public water supply. The reviewing authority prior to preparation of final plans and specifications must approve proposals for use of disinfecting agents other than chlorine. Pilot studies may be required.

4.4 SOFTENING

The softening process selected must be based upon the mineral qualities of the raw water and the desired finished water quality in conjunction with requirements for disposal of sludge or brine waste, cost of plant, cost of chemicals and plant location. Applicability of the process chosen must be demonstrated.

4.4.1 Lime or lime-soda process

Design standards for rapid mix, flocculation and sedimentation are in Section 4.1. Additional consideration must be given to the following process elements.

4.4.1.1 Hydraulics

When split treatment is used, the bypass line should be sized to carry total plant flow, and an accurate means of measuring and splitting the flow must be provided.

4.4.1.2 Aeration

Determinations should be made for the carbon dioxide content of the raw water. When concentrations exceed 10 milligrams per liter, the economics of removal by aeration as opposed to removal with lime should be considered if it has been determined that dissolved oxygen in the finished water will not cause corrosion problems in the distribution system. (See Section 4.5.)

4.4.1.3 Chemical feed point

Lime and recycled sludge should be fed directly into the rapid mix basin.

4.4.1.4 Rapid mix

Rapid mix basins must provide not more than 30 seconds detention time with adequate velocity gradients to keep the lime particles dispersed.

4.4.1.5 Stabilization

Equipment for stabilization of water softened by the lime or lime-soda process is required. (See Section 4.8.)

4.4.1.6 Sludge collection

a. Mechanical sludge removal equipment must be provided in the sedimentation basin.

b. Sludge recycling to the rapid mix should be provided.

4.4.1.7 Sludge disposal

Provisions must be included for proper disposal of softening sludges. (See Section 4.11.)

4.4.1.8 Disinfection

The use of excess lime is not an acceptable substitute for disinfection. (See Section 4.3.)

4.4.1.9 Plant start-up

The plant processes must be manually started following shutdown.

4.4.2 Cation exchange process

Alternative methods of hardness reduction should be investigated when the sodium content and dissolved solids concentration is of concern.

4.4.2.1 Pre-treatment requirements

Iron, manganese, or a combination of the two, should not exceed 0.3 milligrams per liter in the water as applied to the ion exchange resin. Pre-treatment is required when the content of iron, manganese, or a combination of the two, is one milligram per liter or more (see section 4.6.). Waters having 5 units or more turbidity should not be applied directly to the cation exchange softener.

4.4.2.2 Design

The units may be of pressure or gravity type, of either an up flow or down flow design. Automatic regeneration based on volume of water softened should be used unless manual regeneration is justified and is approved by the reviewing authority. A manual override must be provided on all automatic controls.

4.4.2.3 Exchange capacity

The design capacity for hardness removal should not exceed 20,000 grains per cubic foot when resin is regenerated with 0.3 pounds of salt per kilograin of hardness removed.

4.4.2.4 Depth of resin

The depth of the exchange resin should not be less than three feet.

4.4.2.5 Flow rates

The rate of softening should not exceed seven gallons per minute per square foot of bed area and the backwash rate should be six to eight gallons per minute per square foot of bed area. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

4.4.2.6 Freeboard

The freeboard will depend upon the specific gravity of the resin and the direction of water flow. Generally, the wash water collector should be 24 inches above the top of the resin on down flow units.

4.4.2.7 Under drains and supporting gravel

The bottoms, strainer systems and support for the exchange resin must conform to criteria provided for rapid rate gravity filters. (See Sections 4.2.1.6 and 4.2.1.7.)

4.4.2.8 Brine distribution

Facilities should be included for even distribution of the brine over the entire surface of both up flow and down flow units.

4.4.2.9 Cross-connection control

Backwash, rinse and air relief discharge pipes should be installed in such a manner as to prevent any possibility of back-siphonage.

4.4.2.10 Bypass piping and equipment

A bypass must be provided around softening units to produce a blended water of desirable hardness. Totalizing meters must be installed on the bypass line and on each softener unit. The bypass line must have a shutoff valve and should have an automatic proportioning or regulating device. In some installations, it may be necessary to treat the bypassed water to obtain acceptable levels of iron and/or manganese in the finished water.

4.4.2.11 Additional limitations

Silica gel resins should not be used for waters having a pH above 8.4 or containing less than six milligrams per liter silica and should not be used when iron is present. When the applied water contains a chlorine residual, the cation exchange resin must be a type that is not damaged by residual chlorine. Phenolic resin should not be used.

4.4.2.12 Sampling taps

Smooth-nose sampling taps must be provided for the collection of representative samples. The taps must be located to provide for sampling of the softener influent, effluent and blended water. The sampling taps for the blended water must be at least 20 feet downstream from the point of blending. Petcocks are not acceptable as sampling taps. Sampling taps should be provided on the brine tank discharge piping.

4.4.2.13 Brine and salt storage tanks

a. Salt dissolving or brine tanks and wet salt storage tanks must be covered and must be corrosion-resistant.

b. The make-up water inlet must be protected from back-siphonage. Water for filling the tank should be distributed over the entire surface by pipes above the maximum brine level in the tank. The tanks should be provided with an automatic declining level control system on the make-up water line.

c. Wet salt storage basins must be equipped with manholes or hatchways for access and for direct dumping of salt from truck or rail car. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water reservoirs.

d. Overflows, where provided, must be protected with corrosion resistant screens and must terminate with either a turned downed bend having a proper free fall discharge or a self-closing flap valve.

e. Two wet salt storage tanks or compartments designed to operate independently should be provided.

f. The salt must be supported on graduated layers of gravel placed over a brine collection system.

g. Alternative designs, which are conducive to frequent cleaning of the wet salt storage tank may be considered.

4.4.2.14 Salt and brine storage capacity

Total salt storage should have sufficient capacity to provide for at least 30 days of operation.

4.4.2.15 Brine pump or eductor

An eductor may be used to transfer brine from the brine tank to the softeners. If a pump is used, a brine measuring tank or means of metering should be provided to obtain proper dilution.

4.4.2.16 Stabilization

Stabilization for corrosion control must be provided. An alkali feeder must be provided except when exempted by the reviewing authority.

4.4.2.17 Waste disposal

Suitable disposal must be provided for brine waste (See Section 4.11). Where the volume of spent brine must be reduced, consideration may be given to using part of the spent brine for subsequent regeneration.

4.4.2.18 Construction materials

Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping materials. Steel and concrete must be coated with a non-leaching protective coating that is compatible with salt and brine.

4.4.2.19 Housing

Bagged salt and dry bulk salt storage must be enclosed and separated from other operating areas in order to prevent damage to equipment.

4.5 AERATION

Aeration may be used to help remove offensive tastes and odors due to dissolved gases from decomposing organic matter, or to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulfide, etc., and to introduce oxygen to assist in iron and/or manganese removal. The following design criteria are not intended for organics removal facilities.

4.5.1 Natural draft aeration

Design must provide

a. perforations in the distribution pan 3/16 to 1/2 inches in diameter, spaced 1 to 3 inches on centers to maintain a six-inch water depth,

b. for distribution of water uniformly over the top tray,

c. discharge through a series of three or more trays with separation of trays not less than 12 inches,

d. loading at a rate of 1 to 5 gallons per minute for each square foot of total tray area,

e. trays with slotted, heavy wire (1/2 inch openings) mesh or perforated bottoms,

f. construction of durable material resistant to aggressiveness of the water and dissolved gases,

g. protection from loss of spray water by wing carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees,

h. protection from insects by 24-mesh screen.

4.5.2 Forced or induced draft aeration

Devices must be designed to

a. include a blower with weatherproof motor in a tight housing and screened enclosure,

b. insure adequate counter current of air through the enclosed aerator column,

c. exhaust air directly to the outside atmosphere,

d. include a town-turned and 24-mesh screened air outlet and inlet,

e. be such that air introduced in the column must be as free from obnoxious fumes, dust, and dirt as possible,

f. be such that sections of the aerator can be easily reached or removed for maintenance of the interior or installed in a separate aerator room,

g. provide loading at a rate of 1 to 5 gallons per minute for each square foot of total tray area,

h. insure that the water outlet is adequately sealed to prevent unwarranted loss of air,

i. discharge through a series of five or more trays with separation of trays not less than six inches,

j. provide distribution of water uniformly over the top tray,

k. be of durable material resistant to the aggressiveness of the water and dissolved gases.

4.5.3 Pressure aeration

Pressure aeration may be used for oxidation purposes only if pilot plant study indicates the method is acceptable; it is not acceptable for removal of dissolved gases. Filters following pressure aeration must have adequate exhaust devices for release of air. Pressure aeration devices must be designed to

a. give thorough mixing of compressed air with water being treated,

b. provide screened and filtered air, free of obnoxious fumes, dust, dirt and other contaminants.

4.5.4 Other methods of aeration

Other methods of aeration may be used if applicable to the treatment needs. Such methods include but are not restricted to spraying, diffused air, cascades and mechanical aeration. The treatment processes must be designed to meet the particular needs of the water to be treated and are subject to the approval of the reviewing authority.

4.5.5 Protection of aerators

All aerators except those discharging to lime softening or clarification plants must be protected from contamination by birds, insects, wind borne debris, rainfall and water draining off the exterior of the aerator.

4.5.6 Disinfection

Groundwater supplies exposed to the atmosphere by aeration must receive chlorination as the minimum additional treatment.

4.5.7 Bypass

A bypass should be provided for all aeration units.

4.5.8 Corrosion control

The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary. (See Section 4.8.)

4.6 IRON AND MANGANESE CONTROL

Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analyses of representative samples of water to be treated, and receive the approval of the reviewing authority. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design. Consideration should be given to adjusting pH of the raw water to optimize the chemical reaction. Testing equipment and sampling taps must be provided as outlined in Chapter 2.

4.6.1 Removal by oxidation, detention and filtration

4.6.1.1 Oxidation

Oxidation may be by aeration, as indicated in Section 4.5, or by chemical oxidation with chlorine, potassium permanganate, ozone or chlorine dioxide.

4.6.1.2 Detention

a. Reaction - A minimum detention time of 20 minutes must be provided following aeration to insure that the oxidation reactions are as complete as possible. This minimum detention may be omitted only where a pilot plant study indicates no need for detention. The detention basin should be designed as a holding tank with no provisions for sludge collection but with sufficient baffling to prevent short-circuiting.

b. Sedimentation - Sedimentation basins must be provided when treating water with high iron and/or manganese content, or where chemical coagulation is used to reduce the load on the filters. Provisions for sludge removal must be made.

4.6.1.3 Filtration

Filters must be provided and must conform to Section 4.2.

4.6.2 Removal by the lime-soda softening process

See Section 4.4.1.

4.6.3 Removal by manganese greensand filtration

This process consists of a continuous feed of potassium permanganate to the influent of a manganese greensand filter.

a. Provisions should be made to apply the permanganate as far ahead of the filter as practical and to a point immediately before the filter.

b. Other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce the cost of the chemical.

c. Anthracite media cap of at least six inches must be provided over manganese greensand.

d. Normal filtration rate is three gallons per minute per square foot.

e. Normal wash rate is 8 to 10 gallons per minute per square foot.

f. Air washing should be provided.

g. Sample taps must be provided

   1. prior to application of permanganate,

   2. immediately ahead of filtration,

3. at the filter effluent, and

4. should be provided at points between the anthracite media and the manganese greensand media, and halfway down the manganese greensand media.

4.6.4 Removal by ion exchange

This process of iron and manganese removal should not be used for water containing more than 0.3 milligrams per liter of iron, manganese or combination thereof. This process is not acceptable where either the raw water or wash water contains dissolved oxygen.

4.6.5 Sequestration by polyphosphates

Where phosphate treatment is used, a minimum chlorine residual of 0.2 milligrams per liter must be maintained in the distribution system.

a. Feeding equipment must conform to the applicable sections of Part 5.

b. Stock phosphate solutions must be received, stored and dispensed from covered shipping drums. Disinfection of the solution beyond that provided by the manufacturer is not required.

c. Polyphosphates may not be applied ahead of iron and manganese removal treatment. The point of application must be prior to any aeration, oxidation or disinfection if no iron or manganese removal treatment is provided.

d. Liquid polyphosphates must meet the requirements of ANSI/NSF Standard 60. The total phosphate applied may not exceed the maximum concentration allowed by NSF Standard 60.

4.6.6 Sequestration by sodium silicates

Sodium silicate sequestration of iron and manganese is appropriate only for groundwater supplies prior to air contact. On-site pilot tests are required to determine the suitability of sodium silicate for the particular water and the minimum feed needed. Rapid oxidation of the metal ions such as by chlorine or chlorine dioxide must accompany or closely precede the sodium silicate addition. Injection of sodium silicate more than 15 seconds after oxidation may cause detectable loss of chemical efficiency. Dilution of feed solutions much below five per cent silica as SiO_2 should also be avoided for the same reason.

a. Sodium silicate addition is applicable to waters containing up to 2 mg/l of iron, manganese or combination thereof.

b. Chlorine residuals must be maintained throughout the distribution system to prevent biological breakdown of the sequestered iron.

c. The amount of silicate added must be limited to 20 mg/l as SiO_2, but the amount of added and naturally occurring silicate may not exceed 60 mg/l as SiO_2.

d. Feeding equipment must conform to the requirements of Part 5.

e. Sodium silicate may not be applied ahead of iron or manganese removal treatment.

f. Liquid sodium silicate must meet AWWA Standard B404.

4.6.7 Sampling taps

Smooth-nosed sampling taps must be provided for control purposes. Taps must be located on each raw water source, each treatment unit influent and each treatment unit effluent.

4.6.8 Testing equipment must be provided for all plants.

a. The equipment should have the capacity to accurately measure the iron content to a minimum of 0.1 milligrams per liter and the manganese content to a minimum of 0.05 milligrams per liter.

b. Where polyphosphate sequestration is practiced, appropriate phosphate testing equipment must be provided.

4.7 FLUORIDATION

Sodium fluoride, sodium silicofluoride and hydrofluosilicic acid must conform to the applicable AWWA standards. The reviewing authority must approve other fluoride compounds, which may be available. The reviewing authority prior to preparation of final plans and specifications must approve the proposed method of fluoride feed.

4.7.1 Fluoride compound storage

Fluoride chemicals should be isolated from other chemicals to prevent contamination. Compounds must be stored in covered or unopened shipping containers and should be stored inside a building. Unsealed storage units for hydrofluosilicic acid should be vented to the atmosphere at a point outside any building. Bags, fiber drums and steel drums should be stored on pallets.

4.7.2 Chemical feed equipment and methods

In addition to the requirements in Part 5, fluoride feed equipment must meet the following requirements:

a. scales, loss of weight recorders or liquid level indicators, as appropriate, accurate to within five percent of the average daily change in reading must be provided for chemical feeds,

b. feeders must be accurate to within five percent of any desired feed rate,

c. fluoride compound may not be added before lime-soda softening, ion exchange softening, or filtration,

d. the point of application of hydrofluosilicic acid, if into a horizontal pipe, must be in the lower half of the pipe,

e. a fluoride solution must be applied by a positive displacement pump having a stroke rate not less than 20 strokes per minute,

f. anti-siphon devices must be provided for all fluoride feed lines and dilution water lines,

g. a device to measure the flow of water to be treated is required,

h. the dilution water pipe must terminate at least two pipe diameters above the solution tank,

i. water used for sodium fluoride dissolution must be softened if hardness exceeds 75 mg/l as calcium carbonate,

j. fluoride solutions may not be injected to a point of negative pressure,

k. the electrical outlet used for the fluoride feed pump should have a nonstandard receptacle and must be interconnected with the well or service pump,

l. saturators must be of the up flow type and be provided with a meter and backflow protection on the makeup water line.

4.7.3 Secondary controls

Secondary control systems for fluoride chemical feed devices may be required by the reviewing authority as a means of reducing the possibility of overfeed; these may include flow or pressure switches or other devices.

4.7.4 Protective equipment

Protective equipment, as outlined in Section 5.3.4, must be provided for operators handling fluoride compounds.

4.7.5 Dust control

a. Provision must be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust, which may enter the room in which the equipment is installed. The enclosure must be provided with an exhaust fan and dust filter that place the hopper under negative pressure. Air exhausted from fluoride handling equipment must discharge through a dust filter to the outside atmosphere of the building.

b. Provision must be made for disposing of empty bags, drums or barrels in a manner that will minimize exposure to fluoride dusts. A floor drain should be provided to facilitate the hosing of floors.

4.7.6 Testing equipment

Equipment must be provided for measuring the quantity of fluoride in the water. Such equipment is subject to the approval of the reviewing authority.

4.8 STABILIZATION

Water that is unstable due either to natural causes or to subsequent treatment should be stabilized.

4.8.1 Carbon dioxide addition

a. Recarbonation basin design should provide

   1. a total detention time of twenty minutes

   2. two compartments, with a depth that will provide a diffuser submergence of not less than 7.5 feet nor greater submergence than recommended by the manufacturer as follows:

      a. a mixing compartment having a detention time of at least three minutes,

      b. a reaction compartment.

b. Plants generating carbon dioxide from combustion must have open top recarbonation tanks in order to dissipate carbon monoxide gas.

c. Where liquid carbon dioxide is used, adequate precautions must be taken to prevent carbon dioxide from entering the plant from the recarbonation process.

d. Provisions must be made for draining the recarbonation basin and removing sludge.

4.8.2 Acid addition

a. Feed equipment must conform to Chapter 5.

b. Adequate precautions must be taken for operator safety, such as not adding water to the concentrated acid. (See Sections 5.3 and 5.4.)

4.8.3 Phosphates

The feeding of phosphates may be applicable for sequestering calcium in lime-softened water, corrosion control, and in conjunction with alkali feed following ion exchange softening.

a. Feed equipment must conform to Chapter 5.

b. Phosphate must meet the requirements of ANSI/NSF Standard 60.

c. Stock phosphate solutions must be received, stored and dispensed from covered shipping drums. Disinfection of the solution beyond that provided by the manufacturer is not required.

d. Where phosphate treatment is used, a minimum chlorine residual of 0.2 milligrams per liter must be maintained in the distribution system.

4.8.4 "Split treatment"

Under some conditions, a lime-softening water treatment plant can be designed using "split treatment" in which raw water is blended with lime-softened water to partially stabilize the water prior to secondary clarification and filtration. Treatment plants designed to utilize "split treatment" should also contain facilities for further stabilization by other methods.
Bypassing of a portion of the flow from a surface source without complete treatment is subject to the approval of MDEQ.

4.8.5 Alkali feed

Unstable water created by ion exchange softening must be stabilized by an alkali feed. An alkali feeder must be provided for all ion exchange water softening plants except when exempted by the reviewing authority.

4.8.6 Carbon dioxide reduction by aeration

The carbon dioxide content of an aggressive water may be reduced by aeration. Aeration devices must conform to Section 4.5.

4.8.7 Other treatment

Other treatment for controlling corrosive waters by the use of sodium silicate and sodium bicarbonate may be used where necessary. Any proprietary compound must receive the specific approval of the reviewing authority before use. Chemical feeders must be as required in Chapter 5.

4.8.8 Water unstable due to biochemical action in distribution system

Unstable water resulting from the bacterial decomposition of organic matter in water (especially in dead end mains), the biochemical action within tubercles, and the reduction of sulfates to sulfides should be prevented by the maintenance of a free chlorine residual throughout the distribution system.

4.8.9 Control

Laboratory equipment must be provided for determining the effectiveness of stabilization treatment.

4.9 TASTE AND ODOR CONTROL

Provision must be made for the control of taste and odor at all surface water treatment plants. Chemicals must be added sufficiently ahead of other treatment processes to assure adequate contact time for an effective and economical use of the chemicals. Where severe taste and odor problems are encountered, in-plant and/or pilot plant studies are required. If a disinfectant is to be used to control taste and odors, the potential for formation of unacceptable levels of disinfection by-products must be considered.

4.9.1 Flexibility

Plants treating water that is known to have taste and odor problems should be provided with equipment that makes several of the control processes available so that the operator will have flexibility in operation.

4.9.2 Chlorination

Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved. Excessive potential trihalomethane production through this process should be avoided by adequate bench-scale testing prior to design.

4.9.3 Chlorine dioxide

Chlorine dioxide has been generally recognized as a treatment for tastes caused by industrial wastes, such as phenols. However, chlorine dioxide can be used in the treatment of any taste and odor that is treatable by an oxidizing compound. Provisions must be made for proper storing and handling of the sodium chlorite, so as to eliminate any danger of explosion. (See Section 5.4.3.)

4.9.4 Powdered activated carbon

a. Powdered activated carbon should be added as early as possible in the treatment process to provide maximum contact time. Flexibility to allow the addition of carbon at several points is preferred. Activated carbon should not be applied near the point of chlorine application.

b. The carbon can be added as a pre-mixed slurry or by means of a dry-feed machine as long as the carbon is properly wetted.

c. Continuous agitation or resuspension equipment is necessary to keep the carbon from depositing in the slurry storage tank.

d. Provision must be made for adequate dust control.

e. The required rate of feed of carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision should be made for adding from 0.1 milligrams per liter to at least 40 milligrams per liter.

f. Powdered activated carbon must be handled as a potentially combustible material. It should be stored in a building or compartment as nearly fireproof as possible. Other chemicals should not be stored in the same compartment. A separate room should be provided for carbon feed installations. Carbon feeder rooms should be equipped with explosion-proof electrical outlets, lights and motors.

4.9.5 Granular activated carbon

See Section 4.2.1.6 for application within filters.

4.9.6 Copper sulfate and other copper compounds

Continuous or periodic treatment of water with copper compounds to kill algae or other growths must be controlled to prevent copper in excess of 1.0 milligrams per liter as copper in the plant effluent or distribution system. Care must be taken to assure an even distribution.

4.9.7 Aeration

See Section 4.5.

4.9.8 Potassium permanganate

Application of potassium permanganate may be considered, providing the treatment must be designed so that the products of the reaction are not visible in the finished water.

4.9.9 Ozone

Ozonation can be used as a means of taste and odor control. Adequate contact time must be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors. (See Ozone Policy Statement.)

4.9.10 Other methods

The decision to use any other methods of taste and odor control should be made only after careful laboratory and/or pilot plant tests and on consultation with the reviewing authority.

4.10 MICROSCREENING

A microscreen is a mechanical supplement of treatment capable of removing suspended matter from the water by straining. It may be used to reduce nuisance organisms and organic loadings. It may not be used in place of

a. filtration, when filtration is necessary to provide a satisfactory water, or

b. coagulation, in the preparation of water for filtration.

4.10.1 Design

a. must give due consideration to

   1. nature of the suspended matter to be removed,

   2. corrosiveness of the water,

   3. effect of chlorination, when required as pre-treatment,

   4. duplication of units for continuous operation during equipment maintenance;

b. must provide

   1. a durable, corrosion-resistant screen,

   2. by-pass arrangements,

   3. protection against back-siphonage when potable water is used for washing,

   4. proper disposal of wash waters. (See Section 4.11.)

4.11 WASTE DISPOSAL

Provisions must be made for proper disposal of water treatment plant waste such as sanitary, laboratory, clarification sludge, softening sludge, iron sludge, filter backwash water, and brines. All waste discharges are governed by regulatory agency requirements. The requirements outlined herein must, therefore, be considered minimum requirements as state water pollution control authorities may have more stringent requirements. In locating waste disposal facilities, due consideration must be given to preventing potential contamination of the water supply.

Alternative methods of water treatment and chemical use should be considered as a means of reducing waste volumes and the associated handling and disposal problems.

4.11.1 Sanitary waste

The sanitary waste from water treatment plants, pumping stations, and other waterworks installations must receive treatment. Waste from these facilities must be discharged directly to a sanitary sewer system, when available and feasible, or to an adequate on-site waste treatment facility approved by the appropriate reviewing authority.

4.11.2 Brine waste

Waste from ion exchange plants, demineralization plants, or other plants that produce a brine, may be disposed of by controlled discharge to a stream if adequate dilution is available. Surface water quality requirements of the regulatory agency will control the rate of discharge. Except when discharging to large waterways, a holding tank of sufficient size should be provided to allow the brine to be discharged over a twenty-four hour period. Where discharging to a sanitary sewer, a holding tank may be required to prevent the overloading of the sewer and/or interference with the waste treatment process. The effect of brine discharge to sewage lagoons may depend on the rate of evaporation from the lagoons.

4.11.3 Lime softening sludge

Sludge from plants using lime to soften water varies in quantity and in chemical characteristics depending on the softening process and the chemical characteristics of the water being softened. Recent studies show that the quantity of sludge produced is much larger than indicated by stoichiometric calculations. Methods of treatment and disposal are as follows:

a. Lagoons

    1. Temporary lagoons which must be cleaned periodically should be designed on the basis of 0.7 acres per million gallons per day per 100 milligrams per liter of hardness removed based on usable lagoon depth of five feet. This should provide about 2 1/2 years storage. At least two but preferably more lagoons must be provided in order to give flexibility in operation. An acceptable means of final sludge disposal must be provided. Provisions must be made for convenient cleaning.

    2. Permanent lagoons should have a volume of at least four times that for temporary lagoons.

    3. The design of both temporary lagoons and permanent lagoons should provide for

        a. location free from flooding,

        b. when necessary, dikes, deflecting gutters or other means of diverting surface water so that it does not flow into the lagoons,

        c. a minimum usable depth of five feet,

        d. adequate freeboard of at least two feet,

        e. adjustable decanting device,

f. effluent sampling point,

   g. adequate safety provisions, and

   h. parallel operation.

b. The application of liquid lime sludge to farmland should be considered as a method of ultimate disposal. Approval from the appropriate reviewing authority must be obtained. When this method is selected, the following provisions must be made:

   1. Transport of sludge by vehicle or pipeline must incorporate a plan or design, which prevents spillage or leakage during transport.

   2. Interim storage areas at the application site must be kept to a minimum and facilities must be provided to prevent wash off of sludge or flooding.

   3. Sludge may not be applied at times when wash off of sludge from the land could be expected.

   4. Sludge may not be applied to sloping land where wash off could be expected unless provisions are made, for suitable land, to immediately incorporate the sludge into the soil.

   5. Trace metals loading must be limited to prevent significant increases in trace metals in the food chain, phytotoxicity or water pollution.

   6. Each area of land to receive lime sludge must be considered individually and a determination made as to the amount of sludge needed to raise soil pH to the optimum for the crop to be grown.

c. Discharge of lime sludge into sanitary sewers should be avoided since it may cause both liquid volume and sludge volume problems at the sewage treatment plant. This method should be used only when the sewerage system has the capability to adequately handle the lime sludge.

d. Mixing of lime sludge with activated sludge waste may be considered as a means of co-disposal.

e. Disposal at the landfill can be done as either a solid or liquid if the landfill can accept such waste, depending on individual state requirements.

f. Mechanical dewatering of sludge may be considered. Pilot studies on a particular plant waste are required.

g. Calcination of sludge may be considered. Pilot studies on a particular plant waste are required.

h. Lime sludge drying beds are not recommended.

4.11.4 Alum sludge

Lagooning may be used as a method of handling alum sludge. Lagoon size can be calculated using total chemicals used plus a factor for turbidity. Mechanical concentration may be considered. A pilot plant study is required before the design of a mechanical dewatering installation. Freezing changes the nature of alum sludge so that it can be used for fill. Acid treatment of sludge for alum recovery may be a possible alternative. Alum sludge can be discharged to a sanitary sewer. However, initiation of this practice will depend on obtaining approval from the owner of the sewerage system as well as from the regulatory agency before final designs are made.

Lagoons should be designed to produce an effluent satisfactory to the regulatory agency and should provide for:

a. location free from flooding,

b. where necessary, dikes, deflecting gutters or other means of diverting surface water so that it does not flow into the lagoon,

c. a minimum usable depth of five feet,

d. adequate freeboard of at least two feet,

e. adjustable decanting device,

f. effluent sampling point, and

g. adequate safety provisions.

4.11.5 "Red water" waste

Waste filter wash water from iron and manganese removal plants can be disposed of as follows:

4.11.5.1 Sand filters

Sand filters should have the following features:

a. Total filter area, regardless of the volume of water to be handled, should be no less than 100 square feet. Unless the filter is small enough to be cleaned and returned to service in one day, two or more cells are required.

b. The "red water" filter must have sufficient capacity to contain, above the level of the sand, the entire volume of wash water produced by washing all of the production filters in the plant, unless the production filters are washed on a rotating schedule and the flow through the production filters is regulated by true rate of flow controllers. Then sufficient volume must be provided to properly dispose of the wash water involved.

c. Sufficient filter surface area should be provided so that, during any one-filtration cycle, no more than two feet of backwash water will accumulate over the sand surface.

d. The filter may not be subject to flooding by surface runoff or floodwaters. Finished grade elevation must be established to facilitate maintenance, cleaning and removal of surface sand as required. Flashboards or other non-watertight devices may not be used in the construction of filter sidewalls.

e. The filter media should consist of a minimum of twelve inches of sand, three to four inches of supporting small gravel or torpedo sand, and nine inches of gravel in graded layers. All sand and gravel should be washed to remove fines.

f. Filter sand should have an effective size of 0.3 to 0.5 mm and a uniformity coefficient not to exceed 3.5. The use of larger sized sands must be justified by the designing engineer to the satisfaction of the reviewing authority.

g. The filter should be provided with an adequate under-drainage collection system to permit satisfactory discharge of filtrate.

h. Provision must be made for the sampling of the filter effluent.

i. Overflow devices from "red water" filters are not permitted.

j. Where freezing is a problem, provisions should be made for covering the filters during the winter months.

k. "Red water" filters must comply with the common wall provisions contained in Sections 7.1.3 and 8.1.1, which pertain to the possibility of contaminating treated water with an unsafe water.

   The reviewing authority must be contacted for approval of any arrangement where a separate structure is not provided.

4.11.5.2 Lagoons

Lagoons must have the following features:

a. be designed with volume 10 times the total quantity of wash water discharged during any 24-hour period,

b. a minimum usable depth of three feet,

c. length four times width, and the width at least three times the depth, as measured at the operating water level,

d. outlet to be at the end opposite the inlet,

e. a weir overflow device at the outlet end with weir length equal to or greater than depth,

f. velocity to be dissipated at the inlet end.

4.11.5.3 Discharge to community sanitary sewer

Red water can be discharged to a community sewer. However, approval of this method will depend on obtaining approval from the owner of the sewerage system as well as from the regulatory agency before final designs are made. A holding tank is recommended to prevent overloading the sewers.

4.11.5.4 Recycling "Red Water" Wastes

Recycling of supernatant or filtrate from "red water" waste treatment facilities to the head end of an iron removal plant are not allowed except as approved by the reviewing authority.

4.11.6 Waste filter wash water

Waste filter wash water from surface water treatment or lime softening plants should have suspended solids reduced to a level acceptable to the regulatory agency before being discharged. Many plants have constructed holding tanks and returned this water to the inlet end of the plant. The holding tank should be of such a size that it will contain the anticipated volume of waste wash water produced by the plant when operating at design capacity. A plant that has two filters should have a holding tank that will contain the total waste wash water from both filters calculated by using a 15-minute wash at 20 gallons per minute per square foot. In plants with more filters, the size of the holding tank will depend on the anticipated hours of operation. It is recommended that waste filter wash water be returned at a rate of less than 10 percent of the raw water entering the plant. Filter backwash water should not be recycled when the raw water contains excessive algae, when finished water taste and odor problems are encountered, or when trihalomethane levels in the distribution system may exceed allowable levels.

CHAPTER 5
CHEMICAL APPLICATION

5.0 GENERAL

No chemicals may be applied to treat drinking waters unless specifically permitted by the reviewing authority.

5.0.1 Plans and specifications

Plans and specifications must be submitted for review and approval, as provided for in Chapter 2, and must include

a. descriptions of feed equipment, including maximum and minimum feed ranges,

b. location of feeders, piping layout and points of application,

c. storage and handling facilities,

d. specifications for chemicals to be used,

e. operating and control procedures including proposed application rates, and

f. descriptions of testing equipment and procedures.

5.0.2 Chemical application

Chemicals must be applied to the water at such points and by such means as to

a. assure maximum efficiency of treatment,

b. assure maximum safety to consumer,

c. provide maximum safety to operators,

d. assure satisfactory mixing of the chemicals with the water,

e. provide maximum flexibility of operation through various points of application, when appropriate, and

f. prevent backflow or back-siphonage between multiple points of feed through common manifolds.

5.0.3 General equipment design

General equipment design must be such that

a. feeders will be able to supply, at all time, the necessary amounts of chemicals at an accurate rate, throughout the range of feed,

b. chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution,

c. corrosive chemicals are introduced in such a manner as to minimize potential for corrosion,

d. chemicals that are incompatible are not stored or handled together,

e. all chemicals are conducted from the feeder to the point of application in separate conduits,

f. chemical feeders are as near as practical to the feed point,

g. chemical feeders and pumps operate at no lower than 20 per cent of the feed range, and

h. chemicals are fed by gravity where practical.

5.1 FACILITY DESIGN

5.1.1 Number of feeders

a. Where chemical feed is necessary for the protection of the supply, such as chlorination, coagulation or other essential processes,

   1. a minimum of two feeders must be provided, and

   2. the standby unit or a combination of units of sufficient capacity should be available to replace the largest unit during shut-downs;

   3. where a booster pump is required, duplicate equipment should be provided and, when necessary, standby power.

b. A separate feeder must be used for each chemical applied.

c. Spare parts must be available for all feeders to replace parts that are subject to wear and damage.

5.1.2 Control

a. Feeders may be manually or automatically controlled, with automatic controls being designed so as to allow override by manual controls.

b. At automatically operated facilities, chemical feeders must be electrically interconnected with the well or service pump and should be provided a non-standard electrical receptacle.

c. Chemical feed rates must be proportional to flow.

d. A means to measure water flow must be provided in order to determine chemical feed rates.

e. Provisions must be made for measuring the quantities of chemicals used.

f. Weighing scales

   1. must be provided for weighing cylinders, at all plants utilizing chlorine gas,

2. may be required for fluoride solution feed,
3. should be provided for volumetric dry chemical feeders, and
4. should be accurate to measure increments of 0.5 per cent of load.

5.1.3 Dry chemical feeders

Dry chemical feeders must

a. measure chemicals volumetrically or gravimetrically,
b. provide adequate solution water and agitation of the chemical in the solution pot,
c. provide gravity feed from solution pots, and
d. completely enclose chemicals to prevent emission of dust to the operating room.

5.1.4 Positive displacement solution pumps

Positive displacement type solution feed pumps should be used to feed liquid chemicals, but may not be used to feed chemical slurries. Pumps must be sized to match or exceed maximum head conditions found at the point of injection.

5.1.5 Liquid chemical feeders - Siphon control

Liquid chemical feeders must be such that chemical solutions cannot be siphoned into the water supply, by

a. assuring discharge at a point of positive pressure, or
b. providing vacuum relief, or
c. providing a suitable air gap, or
d. other suitable means or combinations as necessary.

5.1.6 Cross-connection control

Cross-connection control must be provided to assure that

a. the service water lines discharging to solution tanks must be properly protected from backflow as required by the reviewing authority,
b. liquid chemical solutions cannot be siphoned through solution feeders into the water supply as required in Section 5.1.5, and
c. no direct connection exists between any sewer and a drain or overflow from the feeder, solution chamber or tank by providing that all drains terminate at least six inches or two pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit or waste receptacle.

5.1.7 Chemical feed equipment location

Chemical feed equipment must

a. be located in a separate room to reduce hazards and dust problems,

b. be conveniently located near points of application to minimize length of feed lines,

c. be readily accessible for servicing, repair, and observation of operation, and

d. be located such that the flow to the rapid mix is by gravity.

5.1.8 In-Plant water supply

In-Plant water supply must be:

a. ample in quantity and adequate in pressure,

b. provided with means for measurement when preparing specific solution concentrations by dilution,

c. properly treated for hardness, when necessary,

d. properly protected against backflow, and

e. obtained from a location sufficiently downstream of any chemical feed point to assure adequate mixing.

5.1.9 Storage of chemicals

a. Space should be provided for:

   1. at least 30 days of chemical supply,

   2. convenient and efficient handling of chemicals,

   3. dry storage conditions, and

   4. a minimum storage volume of 1 1/2 truck loads where purchase is by truck load lots.

b. Storage tanks and pipelines for liquid chemicals must be specific to the chemicals and not for alternates.

c. Chemicals must be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved storage unit.

d. Liquid chemical storage tanks must

   1. have a liquid level indicator, and

   2. have an overflow and a receiving basin or drain capable of receiving accidental spills or overflows.

5.1.10 Solution tanks

a. A means, which is consistent with the nature of the chemical solution must be provided in a solution tank to maintain a uniform strength of solution. Continuous agitation must be provided to maintain slurries in suspension.

b. Two solution tanks of adequate volume may be required for a chemical to assure continuity of supply in servicing a solution tank.

c. Means must be provided to measure the solution level in the tank.

d. Chemical solutions must be kept covered. Large tanks with access openings must have such openings curbed and fitted with overhanging covers.

e. Subsurface locations for solution tanks must

   1. be free from sources of possible contamination, and

   2. assure positive drainage for ground waters, accumulated water, chemical spills and overflows.

f. Overflow pipes, when provided, should

   1. be turned downward, with the end screened,

   2. have a free fall discharge, and

   3. be located where noticeable.

g. Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

h. Each tank must be provided with a valved drain, protected against backflow in accordance with Sections 5.1.5 and 5.1.6.

i. Solution tanks must be located and protective curbing provided so that chemicals from equipment failure, spillage or accidental drainage do not enter the water in conduits, treatment or storage basins.

5.1.11 Day tanks

a. Day tanks must be provided where bulk storage of liquid chemical is provided.

b. Day tanks must meet all the requirements of Section 5.1.10.

c. Day tanks should hold no more than a 30-hour supply.

d. Day tanks must be scale-mounted, or have a calibrated gauge painted or mounted on the side if liquid level can be observed in a gauge tube or through translucent sidewalls of the tank. In opaque tanks, a gauge rod extending above a reference point at the top of the tank, attached to a float may be used. The ratio of the area of the tank to its height must be such that unit readings are meaningful in relation to the total amount of chemical fed during a day.

e. Hand pumps may be provided for transfer from a carboy or drum. A tip rack may be used to permit withdrawal into a bucket from a spigot. Where motor-driven transfer pumps are provided, a liquid level limit switch and an over-flow from the day tank, must be provided.

f. A means, which is consistent with the nature of the chemical solution, must be provided to maintain uniform strength of solution in a day tank. Continuous agitation must be provided to maintain chemical slurries in suspension.

g. Tanks must be properly labeled to designate the chemical contained.

5.1.12 Feed lines

a. should be as short as possible, and

    1. of durable, corrosion-resistant material,

    2. easily accessible throughout the entire length,

    3. protected against freezing, and

    4. readily cleanable;

b. should slope upward from the chemical source to the feeder when conveying gases;

c. must be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixtures conveyed; and

d. should be color-coded.

5.1.13 Handling

a. Carts, elevators and other appropriate means must be provided for lifting chemical containers to minimize excessive lifting by operators.

b. Provisions must be made for disposing of empty bags, drums or barrels by an approved procedure that will minimize exposure to dusts.

c. Provision must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of dust, which may enter the room in which the equipment is installed. Control should be provided by use of

    1. vacuum pneumatic equipment or closed conveyor systems,

    2. facilities for emptying shipping containers in special enclosures, and/or

    3. exhaust fans and dust filters that put the hoppers or bins under negative pressure.

d. Provision must be made for measuring quantities of chemicals used to prepare feed solutions.

5.1.14 Housing

a. Floor surfaces must be smooth and impervious, slip-proof and well drained with 3 inches per 10 feet minimum slope.

b. Vents from feeders, storage facilities and equipment exhaust must discharge to the outside atmosphere above grade and remote from air intakes.

5.2 CHEMICALS

5.2.1 Shipping containers

Chemical shipping containers must be fully labeled to include

a. chemical name, purity and concentration, and

b. supplier name and address.

5.2.2 Specifications

Chemicals must meet AWWA standards and ANSI/NSF Standard 60, where applicable.

5.2.3 Assay

Provisions may be required for assay of chemicals delivered.

5.3 OPERATOR SAFETY

5.3.1 Ventilation

Special provisions must be made for ventilation of chlorine feed and storage rooms.

5.3.2 Respiratory protection equipment

Respiratory protection equipment, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH) must be available where chlorine gas is handled, and must be stored at a convenient location, but not inside any room where chlorine is used or stored. The units must use compressed air, have at least a 30-minute capacity, and be compatible with or exactly the same as units used by the fire department responsible for the plant.

5.3.3 Chlorine leak detection

A bottle of ammonium hydroxide, 56 per cent ammonia solution, must be available for chlorine leak detection; where ton containers are used, a leak repair kit approved by the Chlorine Institute must be provided. Continuous chlorine leak detection equipment is recommended. Where a leak detector is provided it must be equipped with both an audible alarm and a warning light.

5.3.4 Protective equipment

a. At least one pair of rubber gloves, a dust respirator of a type certified by NIOSH for toxic dusts, an apron or other protective clothing and goggles or face mask must be provided for each operator as required by the reviewing authority. A deluge shower and/or eye-washing device should be installed where strong acids and alkalis are used or stored.

b. A water holding tank that will allow water to come to room temperature must be installed in the water line feeding the deluge shower and eye washing device. Other methods of water tempering will be considered on an individual basis.

c. Other protective equipment should be provided as necessary.

5.4 SPECIFIC CHEMICALS

5.4.1 Chlorine gas

a. Chlorine gas feed and storage must be enclosed and separated from other operating areas. The chlorine room must be:

   1. provided with a shatter resistant inspection window installed in an interior wall,

   2. constructed in such a manner that all openings between the chlorine room and the remainder of the plant are sealed, and

   3. provided with doors equipped with panic hardware, assuring ready means of exit and opening outward only to the building exterior.

b. Full and empty cylinders of chlorine gas should be

   1. isolated from operating areas,

   2. restrained in position to prevent upset,

   3. stored in rooms separate from ammonia storage, and

   4. stored in areas not in direct sunlight or exposed to excessive heat.

c. Where chlorine gas is used, the room must be constructed to provide the following:

   1. each room must have a ventilating fan with a capacity that provides one complete air change per minute when the room is occupied,

   2. the ventilating fan must take suction near the floor as far as practical from the door and air inlet, with the point of discharge so located as not to contaminate air inlets to any rooms or structures,

   3. Air inlets should be through louvers near the ceiling,

   4. louvers for chlorine room air intake and exhaust must facilitate airtight closure,

   5. separate switches for the fan and lights must be located outside of the chlorine room and at the inspection window. Outside switches must be protected from vandalism. A signal light indicating fan operation must be provided at each entrance when the fan can be controlled from more than one point,

   6. vents from feeders and storage must discharge to the outside atmosphere, above grade,

7. the room location should be on the prevailing downwind side of the building away from entrances, windows, louvers, walkways, etc.,

8. floor drains are discouraged. Where provided, the floor drains must discharge to the outside of the building and may not be connected to other internal or external drainage systems.

d. Chlorinator rooms should be heated to 60EF, and be protected from excessive heat. Cylinders and gas lines should be protected from temperatures above that of the feed equipment.

e. Pressurized chlorine feed lines may not carry chlorine gas beyond the chlorinator room.

5.4.2 Locker-type chlorine enclosure for a small pump house

This section applies to small systems that wish to avoid the cost of a large chlorine room by installing a small locker-type enclosure to a pump house.

a. The enclosure must be sized such that it is just big enough to house the chlorination equipment. Under no circumstances may it be big enough for a person to get into.

b. Chlorine gas feed equipment and storage must be enclosed and separated from other operating areas

c. Because the enclosure is sized to prevent the entrance of humans, the ventilation (5.3.1), inspection window (5.4.1 a.1) and panic hardware (5.4.1.a.1) requirements of this section are not applicable to the locker type enclosure.

d. The enclosure must be heated.

e. The access doors must be properly secured to prevent unauthorized access and labeled with an appropriate chlorine-warning placard.

5.4.3 Acids and caustics

a. Acids and caustics must be kept in closed corrosion-resistant shipping containers or storage units.

b. Acids and caustics may not be handled in open vessels, but should be pumped in undiluted form from original containers through suitable hose, to the point of treatment or to a covered day tank.

5.4.4 Sodium chlorite for chlorine dioxide generation

Provisions must be made for proper storage and handling of sodium chlorite to eliminate any danger of explosion.

a. Storage

1. Sodium chlorite must be stored by itself in a separate room and preferably should be stored in an outside building detached from the water treatment facility. It must be stored away from organic materials that would react violently with sodium chlorite.

2. The storage structures must be constructed of non-combustible materials.

3. If the storage structure must be located in an area where a fire may occur, water must be available to keep the sodium chlorite area cool enough to prevent decomposition from heat and the resultant explosive conditions.

b. Handling

1. Care should be taken to prevent spillage.

2. An emergency plan of operation should be available for the clean up of any spillage.

3. Storage drums must be thoroughly flushed prior to recycling or disposal.

c. Feeders

1. Positive displacement feeders must be provided.

2. Tubing for conveying sodium chlorite or chlorine dioxide solutions must be Type 1 PVC, polyethylene or materials recommended by the manufacturer.

3. Chemical feeders may be installed in chlorine rooms if sufficient space is provided or facilities meeting the requirements of subsection 5.4.1 must be provided.

4. Feed lines must be installed in a manner to prevent formation of gas pockets and must terminate at a point of positive pressure.

5. Check valves must be provided to prevent the backflow of chlorine into the sodium chlorite line.

CHAPTER 6
PUMPING FACILITIES

6.0 GENERAL

Pumping facilities must be designed to maintain the sanitary quality of pumped water. Subsurface pits or pump rooms and inaccessible installations should be avoided. No pumping station may be subject to flooding.

6.1 LOCATION

The pumping station must be so located that the proposed site will meet the requirements for sanitary protection of water quality, hydraulics of the system and protection against interruption of service by fire, flood or any other hazard.

6.1.1 Site protection

The station must be

a. elevated to a minimum of three feet above the 100-year flood elevation, or three feet above the highest recorded flood elevation, whichever is higher, or protected to such elevations,

b. readily accessible at all times unless permitted to be out of service for the period of inaccessibility,

c. graded around the station so as to lead surface drainage away from the station,

d. protected to prevent vandalism and entrance by animals or unauthorized persons.

6.2 PUMPING STATIONS

Both raw and finished water-pumping stations must

a. have adequate space for the installation of additional units if needed, and for the safe servicing of all equipment,

b. be of durable construction, fire and weather resistant and with outward-opening doors,

c. have floor elevation of at least six inches above finished grade,

d. have underground structure waterproofed,

e. have all floors drained in such a manner that the quality of the potable water will not be endangered. All floors must slope at least three inches in every 10 feet to a suitable drain,

f. provide a suitable outlet for drainage from pump glands without discharging onto the floor.

6.2.1 Suction well

Suction wells must

a. be watertight,

b. have floors sloped to permit removal of water and entrained solids,

c. be covered or otherwise protected against contamination.

6.2.2 Equipment servicing

Pump stations must be provided with

a. crane-ways, hoist beams, eyebolts, or other adequate facilities for servicing or removal of pumps, motors or other heavy equipment,

b. openings in floors, roofs or wherever else needed for removal of heavy or bulky equipment,

c. a convenient tool board, or other facilities as needed, for proper maintenance of the equipment.

6.2.3 Stairways and ladders

Stairways or ladders must

a. be provided between all floors, and in pits or compartments which must be entered,

b. have handrails on both sides, and treads of non-slip material. Stairs are preferred in areas where there is frequent traffic or where supplies are transported by hand. They must have risers not exceeding nine inches and treads wide enough for safety.

6.2.4 Heating

Provisions must be made for adequate heating for

a. the comfort of the operator,

b. the safe and efficient operation of the equipment

In pump houses not occupied by personnel, only enough heat need be provided to prevent freezing of equipment or treatment process.

6.2.5 Ventilation

Ventilation must conform to existing local and/or state codes. Adequate ventilation must be provided for all pumping stations. Forced ventilation of at least six changes of air per hour must be provided for

a. all rooms, compartments, pits and other enclosures below ground floor,

b. any area where unsafe atmosphere may develop or where excessive heat may be built up. Ventilation requirements must consider heat generated by pump motors.

6.2.6 Dehumidification

In areas where excess moisture could cause hazards to safety or damage to equipment, means for dehumidification should be provided.

6.2.7 Lighting

Pump stations must be adequately lighted throughout. All electrical work must conform to the requirements of the American Insurance Association and related agencies and to the relevant state and/or local codes.

6.2.8 Sanitary and other conveniences

All pumping stations that are manned for extensive periods should be provided with potable water, lavatory and toilet facilities. Plumbing must be so installed as to prevent contamination of a public water supply. Wastes must be discharged in accordance with Section 4.11.

6.3 PUMPS

At least two pumping units must be provided. With any pump out of service, the remaining pump or pumps must be capable of providing the maximum daily pumping demand of the system. Additional capacity may be required if storage is inadequate per Section 7.0.1.b of this circular. The pumping units must

a. have ample capacity to supply the peak demand against the required distribution system pressure without dangerous overloading,

b. be driven by prime movers able to operate against the maximum head,

c. have spare parts and tools readily available,

d. be served by control equipment that has proper heater and overload protection for air temperature encountered.

6.3.1 Suction lift

Suction lift must

a. be avoided, if possible,

b. be within allowable limits, preferably less than 15 feet.

If suction lift is necessary, provision must be made for priming the pumps.

6.3.2 Priming

Prime water must not be of lesser sanitary quality than that of the water being pumped. Means must be provided to prevent backsiphonage. When an air-operated ejector is used, the screened intake must draw clean air from a point at least 10 feet above the ground or other source of possible contamination, unless an apparatus approved by the reviewing authority filters the air. Vacuum priming may be used.

6.4 BOOSTER PUMPS

Booster pumps must be located or controlled so that

a. they will not produce negative pressure in their suction lines,

b. the intake pressure is in accordance with section 8.1.1 when the pump is in normal operation,

c. automatic cutoff pressure must be at least 10 psi in the suction line,

d. automatic or remote control devices must have a range between the start and cutoff pressure that will prevent excessive cycling,

e. a bypass is available.

6.4.1 Duplicate pumps

Each booster pumping station must contain not less than two pumps with capacities such that peak demand can be satisfied with the largest pump out of service.

6.4.2 Metering

All booster-pumping stations should contain a totalizer meter.

6.4.3 Inline booster pumps

In addition to the other requirements of this section, inline booster pumps must be accessible for servicing and repairs.

6.4.4 Individual home booster pumps

Individual home booster pumps are not allowed for any individual service from the public water supply main.

6.5 AUTOMATIC AND REMOTE CONTROLLED STATIONS

All automatic stations should be provided with automatic signaling apparatus, which will report when the station is out of service. All remote controlled stations must be electrically operated and controlled and must have signaling apparatus of proven performance. Installation of electrical equipment must conform to the applicable state and local electrical codes and the National Electrical Code.

6.6 APPURTENANCES

6.6.1 Valves

Pumps must be adequately valved to permit satisfactory operation, maintenance and repair of the equipment. If foot valves are necessary, they must have a net valve area of at least 2 1/2 times the area of the suction pipe and they must be screened. Each pump must have a positive-acting check valve on the discharge side between the pump and the shut-off valve.

6.6.2 Piping

In general, piping must

a. be designed so that the friction losses will be minimized,

b. not be subject to contamination,

c. be protected against surge or water hammer,

d. be such that each pump has an individual suction line or that the lines are manifolded so that they will insure similar hydraulic and operating conditions.

e. have a pressure and leakage test performed in accordance with AWWA standards.

6.6.3 Gauges and meters

Each pump

a. must have a standard pressure gauge on its discharge line,

b. should have a compound gauge on its suction line, and must have a threaded port for this gauge if it is not installed.

c. must have recording gauges in the larger stations,

d. should have a means for measuring the discharge.

The station should have indicating, totalizing, and recording metering of the total water pumped.

6.6.4 Water seals

Water seals may not be supplied with water of a lesser sanitary quality than that of the water being pumped. Where pumps are sealed with potable water and are pumping water of lesser sanitary quality the seal must

a. be provided with a break tank open to atmospheric pressure,

b. have an air gap of at least six inches or two pipe diameters, whichever is greater, between the feeder line and the spill line of the tank.

6.6.5 Controls

Pumps, their prime movers and accessories, must be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provision must be made for alternation. Provision must be made to prevent energizing the motor in the event of a backspin cycle. Electrical controls must be located above grade. Equipment must be provided or other arrangements made to prevent surge pressures from activating controls that switch on pumps or activate other equipment outside the normal design cycle of operation.

6.6.6 Auxiliary power

a. When power failure would result in cessation of minimum essential service, sufficient power must be provided to meet average day demand through

   1. connection to at least two independent public power sources, or

   2. portable or in-place auxiliary power.

b. Auxiliary power is not required when

   1. documentation is submitted that shows power outages are infrequent and of short duration, and

   2. fire protection is not diminished by power failure.

6.6.7 Water pre-lubrication

When automatic pre-lubrication of pump bearings is necessary and an auxiliary direct drive power supply is provided, the pre-lubrication line must be provided with a valved bypass around the automatic control so that the bearings can, if necessary, be lubricated manually before the pump is started or the pre-lubrication controls must be wired to the auxiliary power supply.

CHAPTER 7
FINISHED WATER STORAGE

7.0 GENERAL

The materials and designs used for finished water storage structures must provide stability and durability as well as protect the quality of the stored water. Steel structures must follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Other materials of construction are acceptable when properly designed to meet the requirements of Chapter 7.

7.0.1 Sizing

Storage facilities must have sufficient capacity, as determined from engineering studies, to meet domestic demands, and where fire protection is provided, fire flow demands.

a. Fire flow requirements established by the state Fire Marshal and Insurance Services Office must be satisfied where fire protection is provided.

b. The minimum storage capacity (or equivalent capacity) for systems not providing fire protection must be equal to the average daily consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system.

7.0.2 Location of ground-level reservoirs

a. The bottom of reservoirs and standpipes should be placed at the normal ground surface and must be above maximum flood level.

b. When the bottom must be below normal ground surface, it must be placed above the groundwater table. At least 50 per cent of the water depth should be above grade. Sewers, drains, standing water, and similar sources of possible contamination must be kept at least fifty feet from the reservoir. Water main pipe, pressure tested in place to 50 psi without leakage, may be used for gravity sewers at distances greater than 20 feet and less than 50 feet.

c. The top of a reservoir may not be less than two feet above normal ground surface. Clear wells constructed under filters may be excepted from this requirement when the total design gives the same protection.

7.0.3 Protection

All finished water storage structures must have suitable watertight roofs, which exclude birds, animals, insects, and excessive dust.

7.0.4 Protection from trespassers

Locks on access manholes and other necessary precautions must be provided to minimize the potential for vandalism and sabotage.

7.0.5 Drains

No drain on a water storage structure may have a direct connection to a sewer or storm drain. The design must allow draining the storage facility for cleaning or maintenance without causing loss of pressure in the distribution system. Outlets must discharge over a drainage inlet structure or a splash plate and should be designed to minimize erosion.

7.0.6 Overflow

All water storage structures must be provided with an overflow that is brought down to an elevation between 12 and 24 inches above the ground surface, and discharges over a drainage inlet structure or a splash plate. Outlets should be designed to minimize erosion. No overflow may be connected directly to a sewer or a storm drain. All overflow pipes must be located so that any discharge is visible.

a. When an internal overflow pipe is used on elevated tanks, it should be located in the access tube. For vertical drops on other types of storage facilities, the overflow pipe should be located on the outside of the structure.

b. The overflow of a ground-level structure must open downward and be screened with twenty-four mesh non-corrodible screen installed within the pipe at a location least susceptible to damage by vandalism.

c. The overflow pipe must be of sufficient diameter to permit waste of water in excess of the filling rate.

7.0.7 Access

Finished water storage structures must be designed with reasonably convenient access to the interior for cleaning and maintenance. Manholes above the waterline

a. must be framed at least four inches, and preferably six inches, above the surface of the roof at the opening; on ground-level structures, manholes should be elevated 24 to 36 inches above the top or covering sod;

b. must be fitted with a solid watertight cover which overlaps the framed opening and extends down around the frame at least two inches,

c. should be hinged at one side,

d. must have a locking device.

7.0.8 Vents

Finished water storage structures must be vented. Overflows are not considered as vents. Open construction between the sidewall and roof is not permissible. Vents

a. must prevent the entrance of surface water and rainwater,

b. must exclude birds and animals,

c. should exclude insects and dust, as much as this function can be made compatible with effective venting. For elevated tanks and standpipes, four-mesh non-corrodible screen may be used;

d. must, on ground-level structures, terminate in an inverted U construction with the opening 24 to 36 inches above the roof or sod and be covered with twenty-four mesh non-corrodible screen installed within the pipe at a location least susceptible to vandalism.

7.0.9 Roof and sidewall

The roof and sidewalls of all structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.

a. Any pipes running through the roof or sidewall of a finished water storage structure must be welded, or properly gasketed in metal tanks. In concrete tanks, these pipes must be connected to standard wall castings, which were poured in place during the forming of the concrete. These wall castings should have seepage rings imbedded in the concrete.

b. Openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, must be curbed and sleeved with proper additional shielding to prevent the access of surface or floor drainage water into the structure.

c. Valves and controls should be located outside the storage structure so that the valve stems and similar projections will not pass through the roof or top of the reservoir.

d. The roof of concrete reservoirs with earthen cover must be sloped to facilitate drainage. Consideration should be given to installation of an impermeable membrane roof covering.

7.0.10 Drainage of roof

The roof of the storage structure must be well drained. Downspout pipes may not enter or pass through the reservoir. Parapets, or similar construction, which would tend to hold water and snow on the roof, will not be approved unless adequate waterproofing and drainage are provided.

7.0.11 Safety

The safety of employees must be considered in the design of the storage structure. As a minimum, such matters must conform to pertinent laws and regulations of the area where the reservoir is constructed.

a. Ladders, ladder guards, balcony railings, and safely located entrance hatches must be provided where applicable.

b. Elevated tanks with riser pipes over eight inches in diameter must have protective bars over the riser openings inside the tank.

c. Railings or handholds must be provided on elevated tanks where persons must transfer from the access tube to the water compartment.

7.0.12 Freezing

All finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents, must be designed to prevent freezing which will interfere with proper functioning.

7.0.13 Internal catwalk

Every catwalk over finished water in a storage structure must have a solid floor with raised edges so designed that shoe scrapings and dirt will not fall into the water.

7.0.14 Silt stop

The discharge pipes from all reservoirs must be located in a manner that will prevent the flow of sediment into the distribution system. Removable silt stops should be provided.

7.0.15 Grading

The area surrounding a ground-level structure must be graded in a manner that will prevent surface water from standing within 50 feet of it.

7.0.16 Painting and cathodic protection

Proper protection must be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems must meet the requirements of ANSI/NSF Standard 61 or otherwise be acceptable to the reviewing authority. Interior paint must be properly applied and cured. After curing, the coating may not transfer any substance to the water that will be toxic or cause tastes or odors. Prior to placing in service, an analysis for volatile organic compounds is advisable to establish that the coating is properly cured.

b. Wax coatings for the tank interior should not be used on new tanks. Recoating with a wax system is discouraged; however, the old wax coating must be completely removed to use another tank coating.

c. Cathodic protection must be designed and installed by competent technical personnel and a maintenance contract should be provided.

7.0.17 Disinfection

a. Finished water storage structures must be disinfected in accordance with current AWWA Standard C652. Two or more successive sets of samples, taken at 24-hour intervals, must indicate microbiologically satisfactory water before the facility is placed into operation.

b. Disposal of heavily chlorinated water from the tank disinfection process must be in accordance with the requirements of the state pollution control agency.

c. The disinfection procedure (AWWA chlorination method 3, section 4.3 C652) that allows use of the chlorinated water held in the storage tank for disinfection purposes, is not recommended. When that procedure is used, it is recommended that the initial heavily chlorinated water be properly disposed in order to prevent release of water, which may contain various chlorinated organic compounds into the distribution system.

7.1 PLANT STORAGE

The applicable design standards of Section 7.0 must be followed for plant storage.

7.1.1 Wash water tanks

Wash water tanks must be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by Section 4.2.1.10. Consideration must be given to the backwashing of several filters in rapid succession.

7.1.2 Clear well

Clear well storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use.

a. When finished water storage is used to provide contact time for chlorine (see Section 4.3.2) special attention must be given to size and baffling. (See Section 7.1.2.b below.)

b. To ensure adequate chlorine contact time, sizing of the clear well should include extra volume to accommodate depletion of storage during the nighttime for intermittently operated filtration plants with automatic high service pumping from the clear well during non-treatment hours.

c. An overflow must be provided.

7.1.3 Adjacent compartments

Finished water must not be stored or conveyed in a compartment adjacent to unsafe water when a single wall separates the two compartments.

7.1.4 Basins and wet-wells

Receiving basins and pump wet-wells for finished water must be designed as finished water storage structures.

7.2 HYDROPNEUMATIC TANKS

Hydropneumatic (pressure) tanks, when provided as the only storage facility, are acceptable only in very small water systems. When serving more than 50 housing units, ground or elevated storage designed in accordance with Section 7.0.1 should be provided. Pressure tank storage is not to be considered for fire protection purposes. Pressure tanks must meet applicable ASME code requirements. Pressure tanks for which the ASME code does not apply (i.e., those with nominal water containing capacity of 120 gallons or less) must meet ASME code requirements or must satisfactorily pass a hydrostatic test of one and one-half (1.5) times the maximum allowable working pressure of the tank. The maximum allowable working pressure must be marked on each tank.

7.2.1 Location

The tank must be located above normal ground surface and be completely housed.

7.2.2 Sizing

a. The capacity of the wells and pumps in a hydropneumatic system must be at least equal to the peak instantaneous demand. The active storage volume of the hydropneumatic tanks must be sufficient to limit pump cycling to manufacturer's and industry recommendations. Maximum cycling frequency must be determined for the largest pump when consumer demand is one-half (0.5) of the capacity of the largest pump or combination of pumps operated by the same pressure switch. Reduction of required tank volume for systems with alternating pump controls will not be allowed.

b. Sizing of hydropneumatic storage tanks must consider the need for chlorine contact time, as applicable, independent of the requirements in 7.2.2.a above. Tanks with a common inlet and outlet will not be given any credit for chlorine contact time.

7.2.3 Piping

Each tank must have bypass piping or valves to permit operation of the system while it is being repaired or painted.

7.2.4 Appurtenances

a. Each tank must have means of draining, automatic or manual air blow-off, and means for adding air. In addition, each conventional tank (i.e., without an air-water separator) must have a water sight glass and an access manhole. Where practical the access manhole should be at least 24 inches in diameter.

b. Control equipment consisting of a pressure gage, pressure-relieving device, and pressure operated start-stop controls for the pumps must be provided for the hydropneumatic tank system. A shut-off valve may not be installed between the pump and the pressure operated start-stop controls.

c. The pressure-relieving device must prevent the pressure from rising more than 10 percent above the maximum allowable working pressure. The discharge capacity of the pressure-relieving device must be adequately sized. Pressure gages must have a range of no less than 1.2 times the pressure at which the pressure-relieving device is set to function.

7.3 DISTRIBUTION STORAGE

The applicable design standards of Section 7.0 must be followed for distribution system storage.

7.3.1 Pressures

The maximum variation between high and low levels in storage structures providing pressure to a distribution system should not exceed 30 feet. The minimum working pressure in the distribution system should be 35 psi and the normal working pressure should be approximately 60 psi. When static pressures exceed 100 psi, pressure-reducing devices should be provided on mains in the distribution system.

7.3.2 Drainage

Storage structures that provide pressure directly to the distribution system must be designed so they can be isolated from the distribution system and drained for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drain must discharge to the ground surface with no direct connection to a sewer or storm drain.

7.3.3 Level controls

Adequate controls must be provided to maintain levels in distribution system storage structures. Level indicating devices should be provided at a central location.

a. Pumps should be controlled from tank levels with the signal transmitted by telemetering equipment when any appreciable head loss occurs in the distribution system between the source and the storage structure.

b. Altitude valves or equivalent controls may be required for a second and subsequent structures on the system.

c. Overflow and low-level warnings or alarms should be located at places in the community where they will be under responsible surveillance 24 hours a day.

CHAPTER 8
TRANSMISSION MAINS AND DISTRIBUTION SYSTEMS

8.0 MATERIALS

8.0.1 Standards, materials selection

Pipe, fittings, valves and fire hydrants must conform to the latest standards issued by the AWWA, if such standards exist. In the absence of such standards, components meeting other applicable standards may be acceptable to the reviewing authority. Components must also meet the requirements of ANSI/NSF Standard 61 or otherwise be acceptable to the reviewing authority. Special attention must be given to selecting pipe materials, which will protect against both internal and external pipe corrosion.

Where lines are to be slip-lined, slip-lining material must be approved for potable water applications, be installed in accordance with the manufacturer's guidelines, and be installed in a manner that minimizes service interruption.

8.0.2 Permeation of system by organic compounds

Where distribution systems are installed in areas of groundwater contaminated by organic compounds:

a. pipe and joint materials that are not subject to permeation of the organic compounds must be used.

b. non-permeable materials must be used for all portions of the system including water main, service connections and hydrant leads.

8.0.3 Used materials

Water mains, which have been previously used for conveying potable water, may be reused provided they meet the above standards and have been restored practically to their original condition.

8.0.4 Joints

Packing and jointing materials used in the joints of pipe must meet the standards of the AWWA and the reviewing authority. Pipe having mechanical joints or slip-on joints with rubber gaskets is preferred.

8.1 WATER MAIN DESIGN

8.1.1 Pressure

All water mains, including those not designed to provide fire protection, must be sized after a hydraulic analysis based on flow demands and pressure requirements. The system must be designed to maintain a minimum normal working pressure of 35 psi. Maximum normal working pressure should be approximately 60 psi. Minimum pressure under all conditions of flow (e.g. fire flows) must be 20 psi. Minimum required pressures must be based on those occurring at ground level at the highest building sites served by the proposed water mains excluding service line head losses.

8.1.2 Diameter

The minimum size of water main for providing fire protection and serving fire hydrants must be six-inch diameter. Larger size mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure specified in Section 8.1.1.

8.1.3 Fire protection

When fire protection is to be provided, system design must be such that fire flows and facilities are in accordance with the recommendations of the state Fire Marshal and Insurance Services Office.

8.1.4 Small mains

Any departure from minimum requirements must be justified by hydraulic analysis and future water use, and can be considered only in special circumstances.

8.1.5 Hydrants

Water mains not designed to carry fire-flows may not have fire hydrants connected to them.

8.1.6 Dead ends

a. In order to provide increased reliability of service and reduce head loss, dead ends must be minimized by making appropriate tie-ins whenever practical.

b. Where dead-end mains occur, they must be provided with a fire hydrant if flow and pressure are sufficient, or with an approved flushing hydrant or blow-off for flushing purposes. Flushing devices should be sized to provide flows, which will give a velocity of at least 2.5 feet per second in the water main being flushed. Flushing devices may not be directly connected to any sewer.

8.2 VALVES

Sufficient valves must be provided on water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more than 500-foot intervals in commercial districts and at not more than one block or 800-foot intervals in other districts. Where systems serve widely scattered customers and where future development is not expected, the valve spacing should not exceed one mile.

8.3 HYDRANTS

8.3.1 Location and spacing

Hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the state Fire Marshal and Insurance Services Office. Generally, hydrant spacing may range from 350 to 600 feet depending on the area being served.

8.3.2 Valves and nozzles

Fire hydrants should have a bottom valve size of at least five inches, one 4-1/2 inch pumper nozzle and two 2-1/2 inch nozzles.

8.3.3 Hydrant leads

The hydrant lead must be a minimum of six inches in diameter. Auxiliary valves must be installed in all hydrant leads.

8.3.4 Drainage

Hydrant drains should be plugged. When the drains are plugged the barrels must be pumped dry after use during freezing weather. Where hydrant drains are not plugged, a gravel pocket or dry well must be provided unless the natural soils will provide adequate drainage. Hydrant drains may not be connected to or located within 10 feet of sanitary sewers or storm drains.

8.4 AIR RELIEF VALVES; VALVE, METER AND BLOW-OFF CHAMBERS

8.4.1 Air relief valves

At high points in water mains where air can accumulate provisions must be made to remove the air by means of hydrants or air relief valves. Automatic air relief valves may not be used in situations where flooding of the manhole or chamber may occur.

8.4.2 Air relief valve piping

The open end of an air relief pipe from automatic valves must be extended to at least one foot above grade and be provided with a screened, downward-facing elbow. The pipe from a manually operated valve should be extended to the top of the pit. Use of manual air relief valves is recommended wherever possible.

8.4.3 Chamber drainage

Chambers, pits or manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system, may not be connected directly to any storm drain or sanitary sewer, and blow-offs or air relief valves may not be connected directly to any sewer. Such chambers or pits must be drained to the surface of the ground where they are not subject to flooding by surface water, or to absorption pits underground.

8.5 INSTALLATION OF MAINS

8.5.1 Standards

Specifications must incorporate the provisions of the AWWA standards and manufacturer's recommended installation procedures.

8.5.2 Bedding

A continuous and uniform bedding must be provided in the trench for all buried pipe. Backfill material must be tamped in layers around the pipe and to a sufficient height above the pipe to adequately support and protect the pipe. Stones found in the trench must be removed for a depth of at least six inches below the bottom of the pipe.

8.5.3 Cover

All water mains must be covered with sufficient earth or other insulation to prevent freezing.

8.5.4 Blocking

All tees, bends, reducers, plugs and hydrants must be provided with reaction blocking, tie rods or joints designed to prevent movement.

8.5.5 Pressure and leakage testing

All types of installed pipe must be pressure tested and leakage tested in accordance with the latest edition of AWWA Standard C600.

8.5.6 Disinfection

All new, cleaned or repaired water mains must be flushed, disinfected and tested in accordance with AWWA Standard C651.

8.6 SEPARATION OF WATER MAINS, SANITARY SEWERS AND STORM SEWERS

8.6.1 General

The following factors should be considered in providing adequate separation:

a. materials and type of joints for water and sewer pipes,

b. soil conditions,

c. service and branch connections into the water main and sewer line,

d. compensating variations in the horizontal and vertical separations,

e. space for repair and alterations of water and sewer pipes,

f. off-setting of pipes around manholes.

8.6.2 Parallel installation

Water mains must be laid at least 10 feet horizontally from any existing or proposed sewer mains. The distance must be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, the reviewing authority may allow a deviation on a case-by-case basis, if supported by data from the design engineer.

8.6.3 Crossings

Water mains crossing sewers must be laid to provide a minimum vertical distance of 18 inches between the outside of the water main and the outside of the sewer. This must be the case where the water main is either above or below the sewer. At crossings, one full length of water pipe must be located so both joints will be as far from the sewer as possible. Special structural support for the water and sewer pipes may be required.

8.6.4 Exception

The reviewing authority must specifically approve any deviation from the requirements of Sections 8.6.2 and 8.6.3 when it is impossible to obtain the specified separation distances. The individual review engineer may approve a request, when deviation variables are within the constraints of a deviation previously approved by the Department.

8.6.5 Force mains

There must be at least a 10-foot horizontal separation between water mains and sanitary sewer force mains. There must be an 18-inch vertical separation at crossings as required in Section 8.6.3.

8.6.6 Sewer manholes

No water pipe may pass through or come in contact with any part of a sewer manhole.

8.6.7 Separation of water mains from other sources of contamination

Design engineers should exercise caution when locating water mains at or near certain sites such as sewage treatment plants or industrial complexes. Subsurface sewage systems must be located and avoided. The engineer must contact the reviewing authority to establish specific design requirements for locating water mains near any source of contamination.

8.7 SURFACE WATER CROSSINGS

Surface water crossings, whether over or under water, present special problems. The reviewing authority should be consulted before final plans are prepared.

8.7.1 Above-water crossings

The pipe must be adequately supported and anchored, protected from damage and freezing, and accessible for repair or replacement.

8.7.2 Underwater crossings

A minimum cover of two feet must be provided over the pipe. When crossing watercourses that are greater than 15 feet in width, the following must be provided:

a. pipe pulled or floated and lowered into position must be of special construction, having flexible watertight joints; pipe assembled in place may have mechanical joints in lieu of flexible watertight joints.

b. valves must be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves must be easily accessible for operation.

c. means of applying pressure for leakage tests on the isolated section must be provided.

8.8 CROSS-CONNECTIONS AND INTERCONNECTIONS

8.8.1 Cross-connections

There may not be unprotected cross-connections between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water or other contaminating materials may be discharged or drawn into the system. Cross-connections must be eliminated in conformity with Title 17, Chapter 38, Sub-Chapter 3, ARM.

8.8.2 Cooling water

Neither steam, condensate nor cooling water from the engine jackets or other heat exchange devices may be returned to the potable water supply.

8.8.3 Interconnections

The approval of the reviewing authority must be obtained for interconnections between potable water supplies.

8.9 WATER SERVICES AND PLUMBING

8.9.1 Plumbing

Water services and plumbing must conform to relevant local and state plumbing codes, or to the Uniform Plumbing Code as amended by ARM 8.70.302.

8.9.2 Booster pumps

Individual booster pumps are not allowed for any individual service from the public water supply mains.

8.10 SERVICE METERS

Each service connection should be individually metered. New water systems should individually meter each service connection.

8.11 WATER LOADING STATIONS

Water loading stations present special problems since the fill line may be used for filling both potable water vessels and other tanks or contaminated vessels. To prevent contamination of both the public supply and potable water vessels being filled, the following principles must be met in the design of water loading stations:

a. there may not be any backflow to the public water supply.

b. the piping arrangement must prevent contaminant being transferred from a hauling vessel to others subsequently using the station,

c. hoses may not be contaminated by contact with the ground.

8.12 WATER MAIN ABANDONMENT

Water mains must be abandoned in a manner that prevents cross connections and must be entirely or partially removed to prevent future connection to the abandoned main.

APPENDIX A

A.1 General

In addition to the information required in the circular, information on management, operation, maintenance, and financing of the system must be submitted. The purpose of this information is to allow evaluation of a new system for proper system management, operation and maintenance (O&M), and financial planning that provides long-term stability of the new system. The 1996 Safe Drinking Water Act provides for State development of strategies to ensure the managerial, technical, and financial capacity for new community water systems.

Capacity terms are defined as follows based on definitions in Title 36, Chapter 23, Sub-Chapter 1, ARM:

> Managerial capability (capacity) means the management structure of the water system, including but not limited to ownership accountability, staffing, and organization.
>
> Technical capability (capacity) means the physical infrastructure of the water system, including but not limited to the source water adequacy, infrastructure adequacy, and technical knowledge based on information provided.
>
> Financial capability (capacity) means the financial resources of the water system, including but not limited to the revenue sufficiency, credit worthiness, and fiscal controls.

The Department is granted the authority in 75-6-103(2)(f), MCA, to ensure financial viability of proposed public water supply systems (and public sewage systems) as necessary to ensure the capability of the system to meet the requirements of Title 75, Chapter 6, Part 1, MCA.

A separate application form with appropriate guidance is available from the Department to assist in providing the following information.

A.2 Managerial Capacity

Provide the following information:

1. Name, address, and telephone number of the owner(s). If ownership or control of the system is to change in the near future, such as in a subdivision where the developer will eventually relinquish control to the homeowners' association, provide a projected time line for change of ownership.

2. Administrative and management organizational charts. Define the functions and responsibilities of the organization and each administrative/managerial position. For example, if the organization has a secretary, provide a brief description of the secretary's responsibilities.

3. Plans for staffing the system with a certified operator and back-up operator. Provide the name of the operator if an operator has been selected. An operator should be available to operate the system even if the system has not yet become public. If the system is to be operated under contracted services, provide a copy of the contract.

4. A system or plan for maintaining records (including records of operation, service maintenance, and repairs), plans and specifications for construction, as-built drawings, O&M manuals, and compliance information. Preferably, an office space should be dedicated for storing all information that is readily accessible by the operator, manager(s), and owner(s) of the system.

5. A copy of the articles of incorporation, by-laws, or similar documents that:

   a. Define the purpose of the responsible entity.

   b. Describe the procedures for compliance with the requirements of the Secretary of State's Office for creating and maintaining a non-profit association.

   c. List membership and define membership rights (all lot owners should automatically

   d. Define the format and schedule for meetings and requirements for quorums.

   e. Describe the powers and duties of the board of directors.

   f. Describe the process for transferring control of the system from the developer to the lot owners, where applicable.

   g. Explain the procedures for amendment of the by-laws.

   h. Confer authority to assess and collect fees for O&M, monitoring, personnel, capital improvements and equipment replacement.

   i. Establish the service area of the responsible entity.

   j. Confer authority to require water conservation practices, including metering.

   k. Confer authority to require installation of water meters, and to own and maintain water meters, and the authority to bill according to water usage.

   l. Confer authority to require installation of backflow prevention devices, and to own and maintain such devices.

   m. Confer authority and define procedures for disconnection of service (nonpayment, refusal to provide meters or backflow devices or to allow access for maintenance of this equipment).

   Also, provide policies on how delinquent accounts, system violations, fee changes, and customer complaints will be addressed. Please note that homeowners' associations must file their articles of incorporation with the Secretary of State.

6. In the event that the responsible entity becomes insolvent, how will perpetuation of the system be maintained? Has a second party been considered for future ownership in the event that the responsible entity becomes insolvent?

   The managerial plan must allow for:

   a. Efficient operation of the system.

   b. Adequate control of and accountability for the system by the owner(s), manager(s), and operator(s).

c. Adequate resources and accountability for regulatory compliance by the owner(s), manager(s) and operator(s).

d. Dissemination of appropriate information to all customers and regulatory agencies.

A.3 Technical, Operational, and Maintenance Capacity

Provide the following information in the form of an O&M manual that will be available to the operator, owner(s), and manager(s):

1. An explanation of startup and normal operation procedures. Startup should address operation of the system throughout system build out if applicable (i.e., a subdivision will experience varying demands as the subdivision develops and builds out).

2. Will any equipment be leased or rented? Are easement or lease agreements necessary for any portion of the system? If applicable, provide pertinent information (i.e., copy of easement or lease agreement). Are changes in local zoning necessary to protect the proposed source(s)?

3. Record keeping method and system for reporting to the Department.

4. Sampling and analyses program to demonstrate compliance with drinking water standards (Title 17, Chapter 38, Sub-Chapter 2, ARM) for all sources, entry points, treatment, and distribution systems.

5. Staffing and training requirements to operate the system to maintain compliance with drinking water standards (Title 17, Chapter 38, Sub-Chapter 2, ARM).

6. Documentation of a safety program.

7. Documentation of an emergency plan and emergency operating procedures (e.g., in the event of a chemical spill or loss of power).

8. Manufacturer's manuals for all equipment and contact names for service. A routine maintenance program and maintenance schedules must also be included. Forms for recording routine maintenance checks per manufacturer's guidelines should be provided, including frequency of maintenance and anticipated replacement dates for major equipment.

   Items 1 through 5 must be submitted in the form of an O&M manual prior to approval of the system.

   A letter from the applicant must be provided prior to system use indicating that the system (or portion of the system that has been completed to date) was constructed per the approved plans and specifications. As-builts for the system (or portion of the system that has been completed to date) must be provided within 90 days after the system has become operational. The as-builts must include an O&M manual addressing items 1 through 8 and must contain manufacturer's manuals and other pertinent information to complete the O&M manual.

   The system must be operated in a manner that:

   a. Maintains compliance with drinking water standards (Title 17, Chapter 38, Sub-Chapter

2, ARM).

b. Allows effective operation of the system in accordance with the approved plans and specifications.

c. Supplies adequate water, both in terms of quantity and quality.

d. Complies with operating conditions presented in the engineer's report.

A.4 Financial Capacity

The following financial information must be submitted in order to receive system approval:

1. The financial information in Table A-1 must be completed for a 5-year period.

2. O&M rates and capital improvement/replacement rates must be developed based on the information in Table A-1. A capital improvement/replacement plan must be developed for a 20-year period and the rate set accordingly. A reserve fund must be established and maintained to address future replacement of equipment based on anticipated replacement dates.

3. Customers should be metered. If customers are metered, demonstrate how the rates account for metering (cost of meters, cost of operator to read/maintain meters, how rates correspond to meter readings).

4. Connection/system development fee and basis for fee, if applicable.

5. A description of the owner(s) or responsible entity's access to financial capital. If a large sum of money is necessary for replacement, improvement, or expansion, can the owner(s) or responsible entity obtain a loan or grant?

6. Budgetary controls and audit schedule.

7. If the system is privately owned, has the Department of Public Service Regulation been contacted?

8. Provide a financial plan that demonstrates how all improvements will be constructed per the proposed plans and specifications. If bonding or other financial assurance has been provided for improvements with a regulating entity (such as the county), provide information on the bonded improvements.

   The financial plan must demonstrate that:

   a. Revenues match or exceed expenses.

   b. Adequate funds will be maintained for replacement of equipment.

   c. Appropriate reserve accounts will be maintained.

   d. The budget will be controlled, preferably by audits every 3 to 5 years.

   e. The 5-year cash flow presented in Table A-1 is sufficient to properly operate the system.

g. All proposed improvements will be constructed completely and in accordance with the approved plans and specifications.

TABLE A-1 -- SYSTEM BUDGET

Applicant:___________________________________ Completed by:_________________ Date:_______________

5 Year Projections	Year 1 Projected	Year 2 Projected	Year 3 Projected	Year 4 Projected	Year 5 Projected
Enter Year:					
1. Beginning Cash on Hand					
2. Cash Receipts:					
a. Total Revenues					
b. Connection Fees					
c. Interest and Dividend Income					
d. Other Income					
e. Total Cash Revenues (2a thru 2d)					
f. Transfers in/Additional Rev Needed					
g. Loans, Grants or other Cash Injection					
h. Other - please specify					
3. Total Cash Receipts (2e thru 2h)					
4. Total Cash Available (1 + 3)					
5. Operating Expenses					
a. Salaries and wages					
b. Employee Pensions and Benefits					
c. Purchased Water					
d. Purchased Power					
e. Fuel for Power Production					
f. Chemicals					
g. Materials and Supplies					
h. Contractual Services - Engineering					
i. Contractual Services - Other					
j. Rental of Equipment/Real Property					
k. Transportation Expenses					
l. Laboratory					
m. Insurance					
n. Regulatory Commission Expenses					
o. Advertising					
p. Miscellaneous					
q. Total Cash O & M Expenses (5a + 5p)					
r. Replacement Expenditures					
s. Total O M & R Expenditures (5q + 5r)					
t. Loan Principal/Capital Lease Payments					
u. Loan Interest Payments					
v. Transfers Out					
w. Capital Purchases (specify)					
x. Other					
6. Total Cash Paid out (5s thru 5x)					
7. Ending Cash Position (4 - 6)					
8. Number of Customer Accounts					
9. Average Annual User charge Account users:(2a/8)					
10. End of Year Reserves					
a. Debt Service Reserve					
b. Bond Retirement Reserve					
c. Capital Improvement Reserve					
d. Replacement Reserve					
e. Total Reserves (10a thru 10 d)					

11. End of Year Operating Cash (7 - 10e)					